DOCUMENT RESUME

ED 087 480 IR 000 243

AUTHOR	Rouse, William B., Ed.
TITLE	Applications of Operations Research Techniques in Tufts University Libraries.
INSTITUTION	Tufts Univ., Medford, Mass. Coll. of Engineering.
PUB DATE	Dec 73
NOTE	68p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Book Thefts; Library Acquisition; Library Circulation; Library Reference Services; *Library Research; *Library Services; *Operations Research; Periodicals; Reference Materials; Staff Utilization; Statistical Analysis; Tables (Data); *University Libraries; *Use Studies
IDENTIFIERS	Tufts University

ABSTRACT

This collection of papers is based on projects done in conjunction with a senior level/graduate course, "Applications of Operations Research Techniques in Systems Engineering." These seven papers describe research studies which utilized user surveys and/or statistical methods to analyze various library operations. The papers are entitled: 1) "User Opinion of Reference Resources and Services"; 2) "Staffing the Circulation Desk"; 3) "Staffing the Reserve Book Room"; 4) "Book Selection"; 5) "Utility of Engineering Science Periodicals"; 6) "Optimal Tracing Procedures"; and 7) "Automated Protection of Library Collection." (SL)

ED 087 480

APPLICATIONS OF OPERATIONS RESEARCH TECHNIQUES

IN

TUFTS UNIVERSITY LIBRARIES

Edited By

William B. Rouse

Department of Engineering Design

December 1973

U S DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION
THIS DOCUMENT HAS BEEN REPRO
DUCED EXACTLY AS RECEIVED FROM
THE PERSON OR ORGANIZATION ORIGIN
ATING IT. POINTS OF VIEW OR OPINIONS
STATED DO NOT NECESSARILY REPRE
SENT OFFICIAL NATIONAL INSTITUTE OF
EDUCATION POSITION OR POLICY

COLLEGE OF ENGINEERING
TUFTS UNIVERSITY
MEDFORD, MASSACHUSETTS 02155

IR 000 243

FOREWORD

This collection of papers is based on projects done in conjunction with a senior level/graduate course, Applications of Operations Research Techniques in Systems Engineering. During the past semester, this course concentrated on analysis of library operations with twenty-five percent of the class hours devoted to lectures and seminars on that topic. The remaining seventy-five percent of the class hours were devoted to lectures on probability and statistics, queuing theory, linear and dynamic programming, and decision analysis.

The text used was Hillier and Lieberman, Introduction to Operations Research, Holden-Day, 1967. However, Morse, Library Effectiveness, MIT Press, 1968 as well as several other books and journals were used extensively.

Ten students were officially enrolled in the course, but several other individuals, to varying degrees, took part in the library-oriented aspects of the course. Of the total number of people involved with the course there were several professional librarians and social scientists as well as the expected large number of mathematicians and engineers.

The professional staff of the University Libraries were invited to bi-weekly seminars and several were regular guests and offered valuable comments and suggestions. Each project was associated with some particular aspect of the library system and those involved with the project worked with the member of the library staff who had responsibility in the appropriate area.

Because of various time constraints, two projects are not included in this collection. David L. Aach investigated the effects of library temperature on student studying habits and found that temperature variations from approximately 71°F appear to have a negative effect on studying. Talal Findakly considered the need for multiple copies of highly circulated books in the Engineering Library and suggested a decision criterion for ordering multiple copies.

As a last and most important comment, I want to express my gratitude to the University Librarian, Joseph S. Komidar, whose participation in the seminars and enthusiastic support of the projects were key factors in their success. Also, the regular participation in the course of Frederick S. Jones, Head of Acquisitions, and George Beal, Head of Circulation, contributed significantly to the rapport with the Libraries.

Medford, Massachusetts
December 1973

William B. Rouse

TABLE OF CONTENTS

User Opinion of Reference Resources and Services	1
Staffing the Circulation Desk	11
Staffing the Reserve Book Room	24
Book Selection	30
Utility of Engineering Science Periodicals	37
Optimal Tracing Procedures	45
Automated Protection of Library Collections	52

USER OPINION OF REFERENCE RESOURCES AND SERVICES

Douglas P. Rayner
Engineering Design 150, Operations Research
Tufts University

ABSTRACT

With the intention of providing the administrators of the Tufts University Libraries with information on user attitudes concerning reference materials and services, this project entailed designing a survey questionnaire, distributing the survey to the user population, and using the University computer to aid analysis of the user response. Finally, conclusions and suggestions derived from the statistical analyses are presented.

INTRODUCTION

When someone is responsible for providing a service and desires some guage of user opinion, the first tool that comes to mind is often a user survey. But often if the user population is large the administrator is apt to become discouraged by the appearent clerical work involved. This is unfortunate since an incorrect assessment of the work involved might completely discourage use of this powerful tool. It really does not take that long to design a short, concise, multiple choice questionnaire that will enable assessment of user opinion as well as a longer questionnaire, and will undoubtedly be better received by the user population. The newer copying processes are less cost prohibitive than before enabling fast, economical production of the questionnaire. And finally, the use of a statistical package on a medium to large size computer reduces complex statistical analysis to simply transfering the responses to some machine readable form, and creating a simple set of program control commands. An example of a service operation that can benefit from correct information about user opinions is a university or large city library. Since most libraries have rather large user populations, the tools described above lend themselves well to simplifying the task of surveying these large populations. With these facts in mind, this project was initiated.

The project entailed designing a questionnaire with the help of the library staff to determine general user attitude concerning the reference materials and services provided by the Tufts University Library. A two page, 13 question (multiple choice) survey was prepared, and 450 copies were made. Despite predictions by library staff and members of the class that the user response might be minimal, all copies of the survey were taken from a display at the front door by entering students, and 320 were returned to the boxes provided at the front entrance, all in the period of about 12 hours. The responses were then typed into the university DEC System 10 Time-sharing System and one-way and two-way frequency statistics were obtained using the Statistical Package for the Social Sciences (SPSS).

The remainder of this paper describes the questionnaire, and discusses the one-way and relevant two-way frequency statistics obtained. The final pages contained conclusions and suggestions based on these statistics.

THE QUESTIONNAIRE

The final questionnaire (shown on next page) contained 13 questions, and space for comment and criticism. It was printed on one page (two sides) so that the users would not be discouraged by what might have appeared to be a long questionnaire. The first few questions were aimed at classifying the particular user so that some relationships might later be seen between user characteristics and the answers to the more subjective questions. Questions seven and eight, although seemingly identical, were each trying to substantiate and quantify a suspicion that the average user was not sure of what reference materials or reference services were provided by the library. Question nine was included to see if the average user also suspected that his fellow users were unaware of what reference resources were available. In question ten it was assumed that a significant number of users would not be sure of reference resources, and it therefore tried to determine what the probable result would be if the user were made more aware of the present reference resources. This same assumption carried into question eleven where the user user was asked to recommend methods of publicizing the present reference resources. Question twelve was intended to guage the user attitude toward the present dispersed reference materials amongst the various branches of the library as opposed to their attitude toward a consolidated reference center. Question thirteen asked the user to generalize his opinion of the reference materials and services available in the library. Question fourteen was included to allow the user to add any comments he/she felt pertained to the reference resources of the Tufts Library.

ANALYSIS

A table of the frequency of answers to each question is shown on the following page. Results shown as histograms are shown for the more interesting questions. Some of the more frequent comments entered on question fourteen are given below.

1) Desire for acquisition of more new books
2) Concern for the overcrowded conditions due to a lack of a student center which burdens the library with many 'socializers'
3) Concern for the fact that the most needed bound periodicals are often not in the stacks, but rather are checked out.
4) Desire for consolidated stacks to give more study space
5) Desire to have the library open more hours
6) A need for storing more resources on film
7) Desire for a more uniform temperature throughout the building
8) A need for more professional staff on duty evenings to answer questions
9) A better copying machine to produce higher quality copies

Some of the relationships between pairs of questions (crosstabulations) are shown on the next few pages. Outlined below are some of the relevant relationships observed.

1) General opinion of the reference resources related to class and major.
   a) The class and major which most frequently found the reference resources 'poor' were the junior class social science majors
   b) The freshman, sophomore and senior classes each had pre-

This survey is conducted by students in Engineering Design 150, 'Operations Research', with the knowledge and cooperation of the Library Administration.

By conducting this survey, the students hope to obtain information on user attitudes and provide library officials with alternatives for possible changes in library structures and policies in the near future, and for long range planning.

This survey is concerned with reference resources. This includes both reference materials (Encyclopedias, Abstracts, Indexes to Periodical Literature, Dictionaries, etc.) and reference services (meaning any service provided by the reference librarian or by a member of the reference staff).

Please take a few minutes to fill out the survey, and return it to the box provided near where you received the survey. If you take a copy of the survey, but decide not to fill it out, please pass it on. Your cooperation is greatly appreciated.

---

1. What time of day is it as you are filling out this survey?
   1. Morning 2. Afternoon 3. Evening

2. What is your class?
   1. Fresh. 2. Soph. 3. Jr. 4. Sr. 5. Grad. 6. Faculty or Staff
   7. Non-Tufts Student

3. What is your Major Discipline?
   1. Humanities 2. Social Science 3. Natural Science 4. Engineering
   5. Special Studies 6. Does not apply

4. How would you classify your use of the Tufts Library System?
   1. Almost never 2. Rarely 3. Occasionally 4. Frequently 5. Almost nightly

5. In an average semester, how many times would you use a piece of reference material or request service from the reference staff?
   1. Never 2. 1-5 3. 6-10 4. 11-20 5. 21-30 6. More than 30

6. How is your use of the reference resources of the library distributed through the semester?
   1. Does not apply 2. Well distributed throughout the semester
   3. Mostly early in the semester 4. Mostly during the end of semester and exams
   5. Mostly the end of semester, but not during exams 6. Mostly during exam period

7. Do you think you are aware of what reference materials are provided by the library?
   1. yes 2. no

8. Do you think you are aware of what reference services are provided by the library?
   1. yes 2. no

(Continued on back of this page)

9. Do you think the majority of the library users are aware of what reference resources are provided?
   1. yes 2. no 3. not sure

10. If you are unsure of what reference resources are provided, do you think being made aware of them would influence your use of these reference resources?
   1. does not apply 2. considerably 3. somewhat 4. not at all

11. If you think that you yourself and/or the average user are unaware of the reference resources provided, what do you think the library should do to remedy the situation?
   1. Regular informative seminars 2. publish a "How to use the T.U. Library" document
   3. both 1 and 2 4. other (please specify)

12. Do you think all reference materials and services of the Medford campus libraries should be consolidated in Wessell?
   1. yes 2. no 3. not sure

13. What is your general opinion of the reference resources provided by the T.U. Library?
   1. can't say 2. more than adequate 3. adequate 4. needs improving
   5. generally poor

14. Please add any criticism or recommendations you wish concerning the reference resources of the Tufts University Library.

TABLE 1: FREQUENCY OF ANSWERS TO EACH QUESTION

Question #	Relative/Adjusted* Frequency (%) of each answer						
	1	2	3	4	5	6	7
2	16.6	28.0	18.6	25.7	6.2	2.3	2.6
3	21.5	37.8	23.5	10.7	3.6	2.9	0.0
4	2.6	5.5	22.1	42.3	27.4	0.0	0.0
5	7.2	42.0	23.1	16.0	7.5	4.2	0.0
6	19.9/0	42.0/52.4	1.6/2.0	13.0/16.3	21.8/27.2	1.6/2.0	0.0
7	50.5	49.5	0.0	0.0	0.0	0.0	0.0
8	23.5	76.5	0.0	0.0	0.0	0.0	0.0
9	2.6	51.5	45.9	0.0	0.0	0.0	0.0
10	24.1/0	30.6/40.3	39.7/52.4	5.5/7.3	0.0	0.0	0.0
11	2.0	64.2	24.4	9.5	0.0	0.0	0.0
12	33.9	37.5	28.7	0.0	0.0	0.0	0.0
13	31.9/0	2.3/3.3	19.9/29.2	34.2/50.2	11.7/17.2	0.0	0.0

* Adjusted frequencies are computed after answers that are considered missing such as 'does not apply' and 'can not say' are removed.

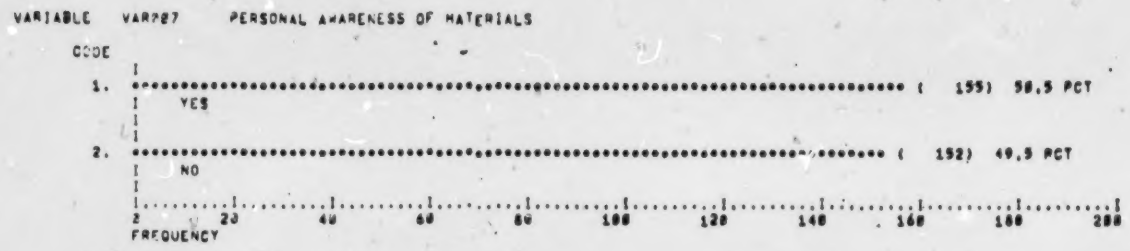
** Question one was discarded since the surveys were not being handed out during all times of the day.

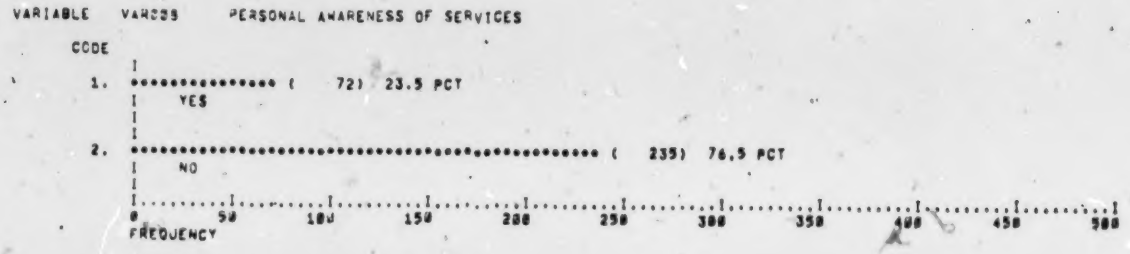
- -

dominantly 'needs improving' attitudes

c) The humanities majors were more frequently of the 'more than adequate' opinion

2) Class and major related to frequency of library use
   a) The class with the most frequent 'almost never' response was the freshman class
   b) The class with the most frequent 'almost nightly' response was the senior class
   c) Natural science majors tend to use the library frequently but are not as frequent users of reference resources
   d) Engineering students use the library mostly for reference purposes
3) Major related to personal awareness of reference materials and services
   a) Humanities, social science, and natural science majors seemed to be more aware of reference materials than engineering majors or non-Tufts students
4) Personal awareness of reference materials related to general opinion of the reference resources
   a) Both the users who felt they were aware of the reference materials available and those who felt they were unaware of these materials had the same distribution of opinions on resources in general


VARIABLE VAR027 PERSONAL AWARENESS OF MATERIALS
CODE
1. YES (155) 50.5 PCT
2. NO (152) 49.5 PCT
0 20 40 60 80 100 120 140 160 180 200
FREQUENCY


VARIABLE VAR028 PERSONAL AWARENESS OF SERVICES
CODE
1. YES (72) 23.5 PCT
2. NO (235) 76.5 PCT
0 50 100 150 200 250 300 350 400 450 500
FREQUENCY

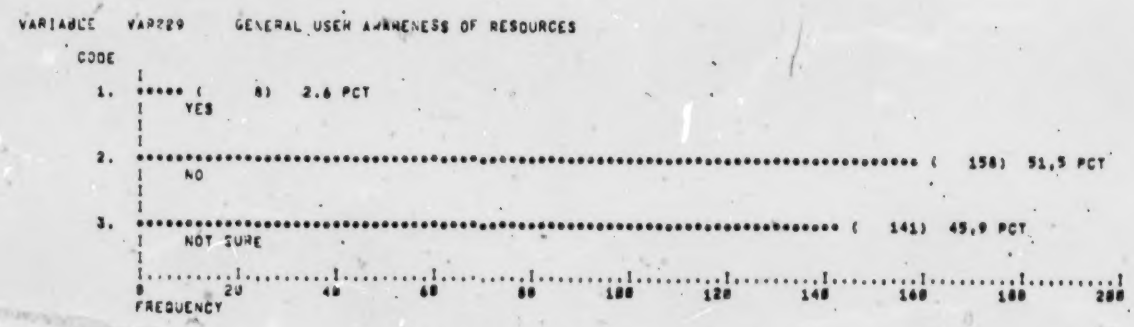
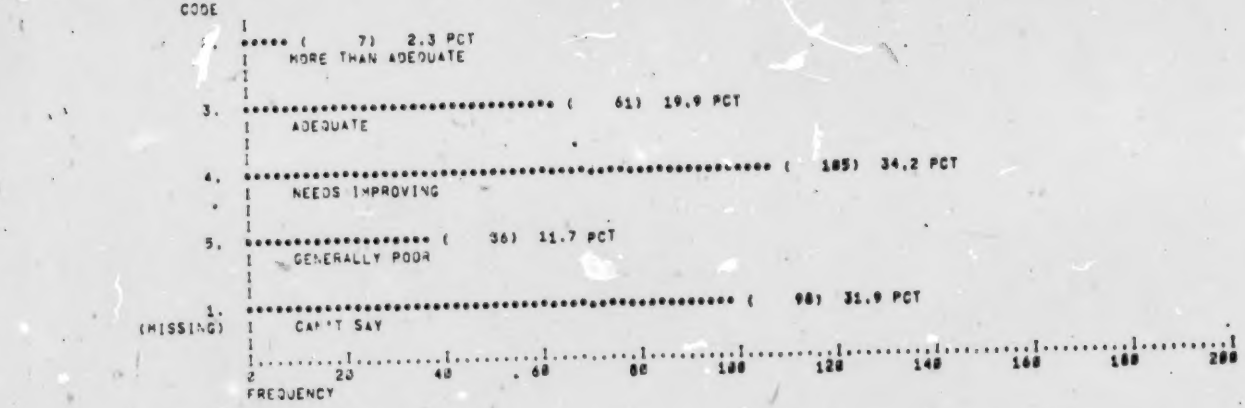

VARIABLE VAR029 GENERAL USER AWARENESS OF RESOURCES
CODE
1. YES (8) 2.6 PCT
2. NO (158) 51.5 PCT
3. NOT SURE (141) 45.9 PCT
0 20 40 60 80 100 120 140 160 180 200
FREQUENCY

TABLE 2: HISTOGRAMS OF THE RESULTS OF QUESTIONS 7,8,9

VARIABLE VAR013 GENERAL OPINION


CODE
2. ***** (7) 2.3 PCT
MORE THAN ADEQUATE
3. ********** (61) 19.9 PCT
ADEQUATE
4. ********** (105) 34.2 PCT
NEEDS IMPROVING
5. ********** (36) 11.7 PCT
GENERALLY POOR
1. ********** (98) 31.9 PCT
(MISSING) CAN'T SAY
0 20 40 60 80 100 120 140 160 180 200
FREQUENCY

VARIABLE VAR010 ASSUMED RESULTS OF MORE PUBLICITY

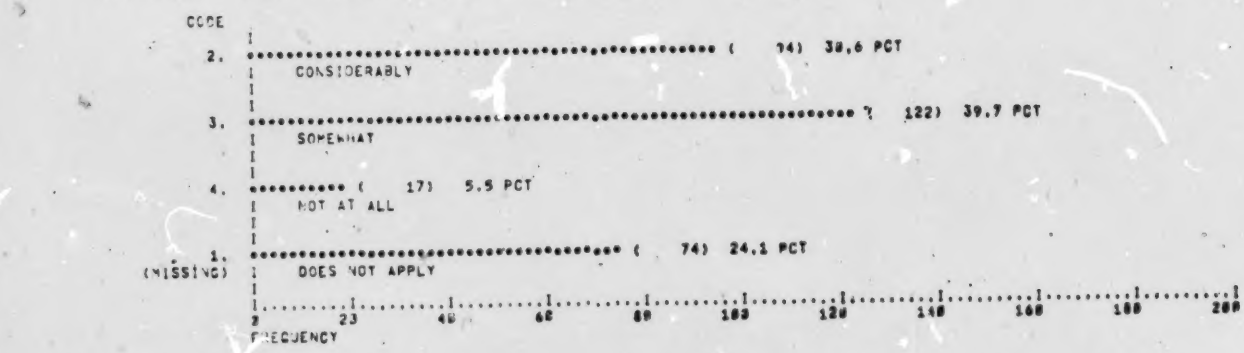

CODE
2. ********** (74) 38.6 PCT
CONSIDERABLY
3. ********** (122) 39.7 PCT
SOMEWHAT
4. ********** (17) 5.5 PCT
NOT AT ALL
1. ********** (74) 24.1 PCT
(MISSING) DOES NOT APPLY
0 20 40 60 80 100 120 140 160 180 200
FREQUENCY

TABLE 3: HISTOGRAM OF THE RESULTS OF QUESTIONS 10,13

CROSSTABULATION OF

VAR227 PERSONAL AWARENESS OF MATERIALS BY VAR818 ASSUMED RESULTS OF MORE PUBLICITY

PAGE 1 OF 1

VAR227	VAR818 CONSIDERABLY 2.1	SOMEWHAT 3.1	NOT AT ALL 4.1	ROW TOTAL
1. YES	38	54	8	99
	32.6	58.7	6.7	39.5
	31.9	44.3	47.1	
	12.9	23.2	3.4	
2. NO	64	68	9	141
	45.4	48.2	6.4	60.5
	68.1	55.7	52.9	
	27.5	29.2	3.9	
COLUMN TOTAL	94	122	17	233
	40.3	52.4	7.3	100.0

CHI SQUARE = 3.82782 WITH 2 DEGREES OF FREEDOM
CRAMER'S V = .12317
CONTINGENCY COEFFICIENT = .12713
KENDALL'S TAU B = -.12245
KENDALL'S TAU C = -.12643
GAMMA = -.23461
SOMER'S D = -.11334

CROSSTABULATION OF

VAR228 PERSONAL AWARENESS OF SERVICES BY VAR818 ASSUMED RESULTS OF MORE PUBLICITY

PAGE 1 OF 1

VAR228	VAR818 CONSIDERABLY 2.1	SOMEWHAT 3.1	NOT AT ALL 4.1	ROW TOTAL
1. YES	7	18	5	30
	23.3	60.0	16.7	12.9
	7.4	14.8	29.4	
	3.0	7.7	2.1	
2. NO	87	104	12	203
	42.9	51.2	5.9	87.1
	92.6	85.2	70.6	
	37.3	44.6	5.2	
COLUMN TOTAL	94	122	17	233
	40.3	52.4	7.3	100.0

CHI SQUARE = 6.99732 WITH 2 DEGREES OF FREEDOM
CRAMER'S V = .17353
CONTINGENCY COEFFICIENT = .17075
KENDALL'S TAU B = -.15548
KENDALL'S TAU C = -.11808
GAMMA = -.42868
SOMER'S D = -.09861

TABLE 4: SOME OF THE MORE INTERESTING CROSSTABULATIONS

5) General personal awareness of reference resources related to assumed results of more publicity of reference resources
   a) 85% of those aware of resources and 95% of those who were unaware of reference resources believed their use of resources would increase at least somewhat
6) User desire for consolidation related to resource use, and use distribution throughout the semester
   a) People who never use the resources and people who make frequent use of the resources responded more often 'no' to a need for consolidation
   b) People who use the library at particular times during the semester were more interested in consolidation than the people who use the the library on a regular basis
7) Frequency of library use related to general opinion of reference resources
   a) The more people used the library the larger the proportion of 'adequate' opinions
8) Frequency of library use related to assumed results of more publicity of the reference resources
   a) Those who used the library very infrequently thought their usage would not increase if resources were more publicized
   b) The more frequent the use, the larger the percentage who believed their use would increase at least somewhat if resources were more publicized

CONCLUSIONS

Since the following trends were observed in the analysis of the results of the survey:

- Almost 50% of respondents were unaware of reference materials available
- More than 75% of respondents were unaware of the reference services available
- Over 80% of all users whether aware of resources or not felt their use of reference resources would increase at least somewhat
- The users were interested in seminars and a summary document to help publicize the present resources available
- The most frequently added comment concerned the overcrowded conditions of the library, and the suspicion that this was due to a lack of a student center
- The second most frequent comment concerned the seemingly constant unavailability of important bound periodicals

and since there are probably no new, readily available funds to do do more than continue the present acquisition policy in the reference department, the following suggestions are presented:

- The library staff should try to compile a brief summary document listing the most frequently used reference materials available in the library including information on where to find the complete list of reference materials, and information on the services provided by the refer- staff
- The library staff should suggest that the University accelerate plans to set up a student center, and give full support to any such plan

- The library staff should seriously consider placing a copying machine in the periodical area so that students can easily copy desired information, and then change policy to state that bound periodicals may not be taken from the library
- The library staff should, on a periodical basis, try to survey user opinion concerning all aspects of library operation, to help provide the best service possible

ACKNOWLEDGEMENTS

The author is grateful to Ms. Jean F. Butt, head of reference and special collections services, Tufts University Library, and her staff for helping to design the questionnaire. The author is also grateful to Mr. George Beal, head of circulation and building services, Tufts University Library for his help in the logistical planning of the survey distribution.

REFERENCES

Nie, N., Bent, D., Hull, C. Statistical Package for the Social Sciences, McGraw-Hill Company, 1970.

STAFFING THE CIRCULATION DESK

Ramesh G. Nar, Graduate Student of Engineering Design,
Tufts University, Medford, Massachusetts 02155

ABSTRACT

This paper presents a technique for staffing the circulation desk. The technique used is the application of queueing theory. The technique presented here can be used for staffing other desks having similar characteristics. The staffing done in this problem is for existing system. Data required for staffing the circulation desk was collected at the circulation desk of Wessell Library. The data is analyzed and finally the number of servers required on the circulation desk is obtained.

INTRODUCTION

The functions of the circulation desk is to issue the books and also to answer inquiries either by telephone or in person. There is one circulation desk in Wessell Library. Also, there is a telephone at the circulation desk.

Generally, the number of servers required depends upon the arrival rate of inquiries and service rate of servers. As the arrival rate increases, servers become busier and at some point it will be necessary to increase the number of servers. The service rate depends upon the task to be performed and also upon the efficiency of servers.

To get the average arrival rate and average service rate an appropriate model is assumed. Application of queueing theory will lead to the proposed staffing policy.

DATA COLLECTION

After conversation with the librarian, it was found that particular hours of the day are of interest. Data was obtained for line length at an interval of fifteen minutes during the hours of interest. This data was collected during the period of October 25, 1973 to November 6, 1973. Line length was taken such that most of the library hours are covered. This data is given in Table 1. Line length means the number of persons waiting in front of the circulation desk (including the persons being serviced).

TIME PERIOD	LINE LENGTH OF AN INTERVAL OF 15 MIN.			
8 - 9	0 1 1 0 -	- 1 1 2 0		
9 - 10	0 1 2 2 1	0 0 2 1 1		
10 - 11	1 1 2 2 3			
11 - 12	1 2 3 2 1			
12 - 13	1 1 2 4 5			
13 - 14	1 1 1 3 0	0 0 0 1 3	3 3 3 2 4	
14 - 15	0 2 1 1 0	3 3 3 2 1	4 2 2 1 1	
15 - 16	1 0 2 1 3			
16 - 17	0 3 1 3 1	3 0 1 4 2		
17 - 18	1 2 0 1 2	2 0 1 0 2	2 0 2 1 1	
18 - 19	2 1 0 1 0	3 0 2 3 3		
19 - 20	3 1 2 0 0	0 2 1 0 0		
20 - 21	0 2 1 0 2			
21 - 22	2 1 1 0 0			

TABLE 1. LINE LENGTH DATA

The average service rate was determined by collecting data between October 31, 1973 and November 2, 1973. This data is tabulated in Table 2.

SERVICE TIME Min.	FREQUENCY (No. of Services)	SERVICE TIME Min.	FREQUENCY (No. of Services)
0 - 0.5	31	5.0 - 5.5	2
0.5 - 1.0	40	5.5 - 6.0	0
1.0 - 1.5	38	6.0 - 6.5	0
1.5 - 2.0	7	6.5 - 7.0	0
2.0 - 2.5	4	7.0 - 7.5	0
2.5 - 3.0	4	7.5 - 8.0	0
3.0 - 3.5	2	8.0 - 8.5	0
3.5 - 4.0	1	8.5 - 9.0	0
4.0 - 4.5	1	9.0 - 9.5	1
4.5 - 5.0	0	9.5 -10.0	1

TABLE 2. SERVICE TIME PERIOD AND NO. OF SERVICES (in person)

Data for inquiries by telephone was collected during the period October 31, 1973 to November 29, 1973. This data is tabulated in Table 3.

Date	Time Period	Time for each Inquiry in Sec.					Total Inquiries
10-31-73	17 - 18	38	113	83	216		4
	18 - 19	173	49				2
	19 - 20	83	191				2
11- 1-73	12 - 13	317	93	44			3
	13 - 14	15	74	209	132	321	5
	14 - 15	211	93				2
11- 2-73	8 - 9	33					2
	9 - 10	0					0
	10 - 11	119	214				2
11- 4-73	18 - 19	103	37	49	312	17	5
	19 - 20	43	54	271	162	109	4
11- 5-73	15 - 16	179	22	143			3
	16 - 17	93					1
	17 - 18	114	36				2
11- 6-73	13 - 14	311					1
	14 - 15	203					1
11-28-73	8 - 9	64					1
	9 - 10	34	127	93	193		4
	15 - 16	205	113				2
	16 - 17	314	273	33	78	97	5
11-29-73	10 - 11	243	287	257	131	163	5

TABLE 3. TELEPHONE INQUIRIES

ANALYSIS

Mean line length, L, for each time period is obtained simply by summing up the line lengths and dividing by the total number of measurements during that period. This mean line length suggests that on the average, there will be that many people in the line at the desk. These values are tabulated in Table 4.

Time Period	Mean Line Length L	No. of Measurements N
8 - 9	0.75	8
9 - 10	1.0	10
10 - 11	1.8	5
11 - 12	1.8	5
12 - 13	2.6	5
13 - 14	1.6	15
14 - 15	1.73	15
15 - 16	1.6	5
16 - 17	1.8	10
17 - 18	1.13	15
18 - 19	1.5	10
19 - 20	0.9	10
20 - 21	1.0	5
21 - 22	0.8	5

TABLE 4. CALCULATIONS OF L

From Table 2, the histogram of the service time (in person) was drawn and is shown in Figure 1. It shows that frequency is highest when the service time is 0.5 to 1 minute.

The cumulative service time distribution was obtained. The probability that service time is greater than time t is shown in Table 5 - and graph of the service time distribution is shown in Figure 2.

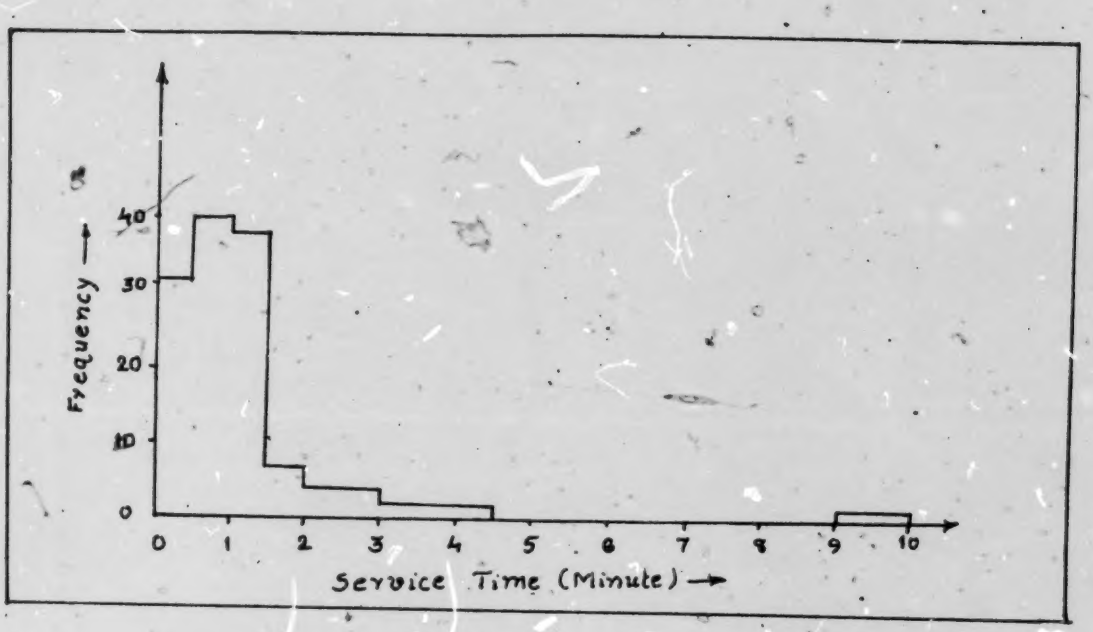


Figure 1. Histogram of Service Time (in person)

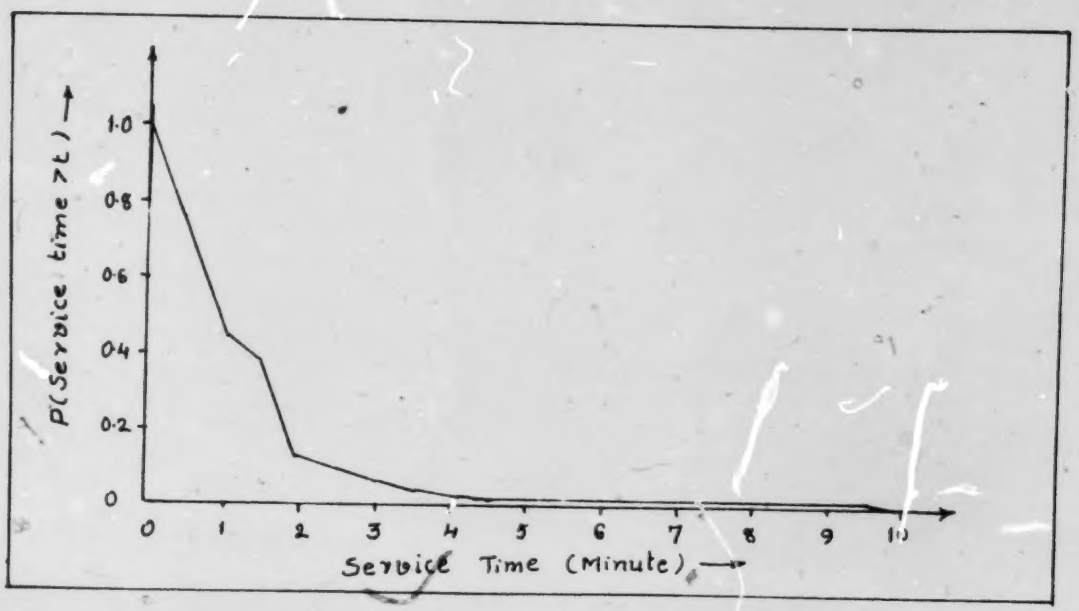


Figure 2. Cumulative Service Time Distribution (in person)

Service Time	Inquiries (Service Time > t)	Probability (Service Time > t)
0	132	1
0.5	101	0.765
1.0	61	0.462
5.5	23	0.377
2.0	16	0.121
2.5	12	0.091
3.0	8	0.0606
3.5	6	0.0455
4.0	4	0.0303
4.5	4	0.0303
5.0	4	0.0303
5.5	2	0.015
6.0	2	0.015
6.5	2	0.015
7.0	2	0.015
7.5	2	0.015
8.0	2	0.015
8.5	2	0.015
9.0	2	0.015
9.5	1	0.008
10.0	0	0.0

TABLE 5. CUMULATIVE SERVICE TIME DISTRIBUTION (in person)

As seen from the graph, service time appears to be exponentially distributed. Therefore, the area under the curve will be the average (in person) service time $1/\mu_1$ (Ref. 1).

[1] Calculating the area,

$$\mu_1 = \frac{1}{1.323} = 0.755 \quad \text{services/minute.}$$

While collecting the data for line length, there were always two servers at the desk. From reference [1], for a two server model having Poisson input and exponential service time, it can be shown that

[2] $$\rho = -\frac{1}{L} + \sqrt{\frac{1}{L^2} + 1}$$

where ρ is the utilization defined as the fraction of time each server is busy. For each time period utilization factor is obtained.

[3] $$\rho = \frac{\lambda_1}{s\mu_1}$$

Using this formula mean arrival rate (in person), λ_1 is obtained. The values of utilization and mean arrival rate are shown in Table 6.

Time Period	Mean Line Length L	Utilization Factor ρ	Mean Arrival Rate $\lambda_1 = s\rho\mu_1$
8 - 9	0.75	0.335	0.490
9 - 10	1.0	0.414	0.625
10 - 11	1.8	0.585	0.874
11 - 12	1.8	0.585	0.874
12 - 13	2.6	0.689	1.039
13 - 14	1.6	0.554	0.836
14 - 15	1.73	0.574	0.866
15 - 16	1.6	0.554	0.836
16 - 17	1.8	0.585	0.874
17 - 18	1.13	0.450	0.681
18 - 19	1.5	0.535	0.808
19 - 20	0.9	0.385	0.581
20 - 21	1.0	0.414	0.625
21 - 22	0.8	0.350	0.528

TABLE 6. UTILIZATION AND MEAN ARRIVAL RATE λ_1 (in person)

Values of the mean arrival rate (in-person) during each time period is obtained and mean service rate is also obtained. This is only for in-person inquiries. Now inquiries by telephone will be considered. It is found while discussing with librarian that inquiries by telephone are much less frequent than inquiries in person at the circulation dest. Therefore, mean arrival rate λ_2 (phone) for each time period was found by taking average inquiries per minute during that time period. Mean arrival rate is tabulated in Table 7.

Time Period	Mean Arrival Rate λ_2
8 - 9	0.017
9 - 10	0.034
10 - 11	0.058
11 - 12	0.050
12 - 13	0.050
13 - 14	0.050
14 - 15	0.025
15 - 16	0.042
16 - 17	0.050
17 - 18	0.050
18 - 19	0.058
19 - 20	0.058
20 - 21	0.034
21 - 22	0.034

TABLE 7. MEAN ARRIVAL RATE λ_2 (by phone)

From Table 3 number of services that had service times greater than t were obtained. The probability for service time greater than t was then determined. This probability is tabulated in Table 8.

Service Time	No. of Services Service Time >t	P (Service time >t
0	55	1
0.5	50	0.91
1.0	42	0.76
1.5	36	0.65
2.0	25	0.45
2.5	21	0.38
3.0	17	0.31
3.5	12	0.22
4.0	8	0.15
4.5	7	0.13
5.0	5	0.09

TABLE 8. CUMULATIVE SERVICE TIME DISTRIBUTION (by phone)

The service time distribution is shown in Figure 3. It is approximately exponentially distributed so the area under the curve is equal to $1/\mu_2$ i.e. mean service time. Thus,

[4] $$\mu_2 = 0.444 \text{ customers/min.}$$

Mean arrival rate in person λ_1 and mean arrival rate by telephone λ_2 for each time period is known and also the mean service rate in person and by telephone μ_1 and μ_2 respectively are now known. Therefore, total arrival rate and mean service rate for each time period are obtained using the following relationships.

[5] $$\lambda = \lambda_1 + \lambda_2$$

[6] $$\mu = \frac{\lambda_1}{\lambda_1 + \lambda_2} \mu_1 + \frac{\lambda_2}{\lambda_1 + \lambda_2} \mu_2$$

Values of λ and μ obtained for each time period are tabulated in Table 9.

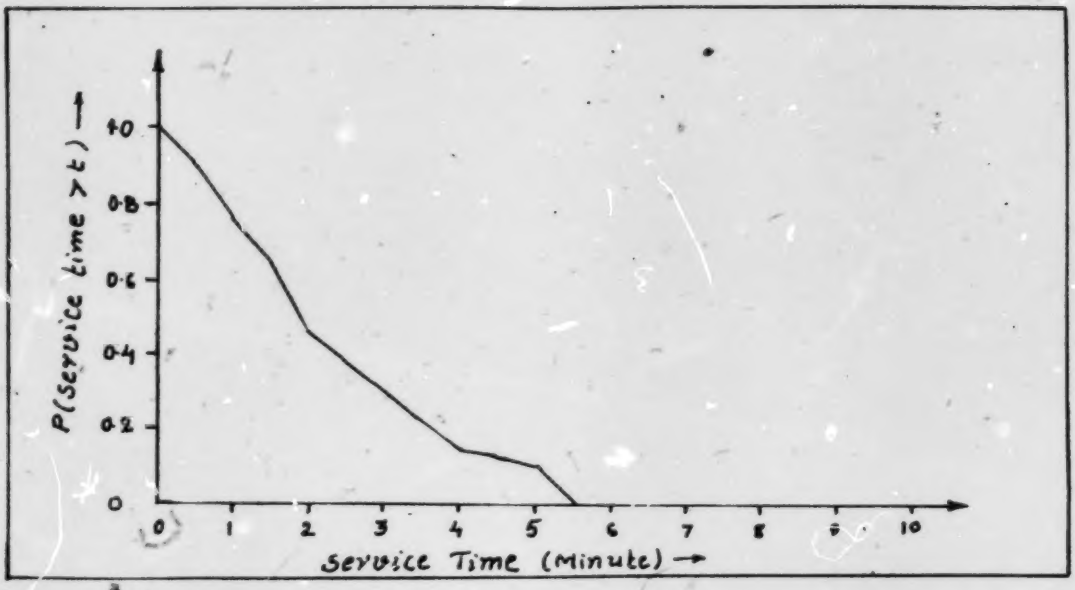


Figure 3. Cumulative Service Time Distribution (by telephone)

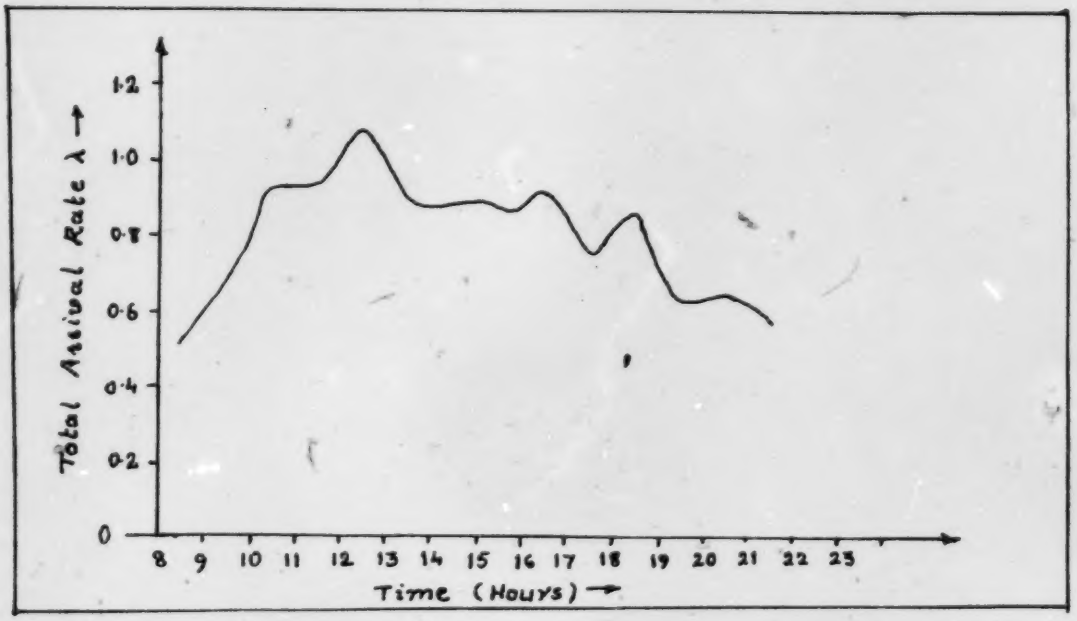


Figure 4. Total Arrival Rate v/s Library Hours

Time Period	Mean Line Length L	Mean Arrival Rate λ_1	Mean Arrival Rate λ_2	Total Arrival Rate λ	Average Service Rate μ
8 - 9	0.75	0.490	0.017	0.507	0.745
9 - 10	1.0	0.625	0.034	0.659	0.740
10 - 11	1.8	0.874	0.058	0.932	0.734
11 - 12	1.8	0.874	0.050	0.924	0.730
12 - 13	2.6	1.039	0.050	1.089	0.739
13 - 14	1.6	0.836	0.050	0.886	0.737
14 - 15	1.73	0.866	0.025	0.891	0.747
15 - 16	1.6	0.836	0.042	0.878	0.741
16 - 17	1.8	0.874	0.050	0.926	0.738
17 - 18	1.13	0.681	0.050	0.731	0.735
18 - 19	1.5	0.808	0.058	0.866	0.735
19 - 20	0.9	0.581	0.058	0.639	0.726
20 - 21	1.0	0.625	0.034	0.659	0.739
21 - 22	0.8	0.528	0.034	0.562	0.738

TABLE 9. CALCULATIONS OF λ and μ

Total arrival rate versus time is plotted in Figure 4. From the graph it is seen that the peak occurs during periods 12 to 13, i.e. the servers are more busy during this period.

Utilization factor ρ for each time period for different numbers of servers was obtained using the formula

$$\rho = \frac{\lambda}{s\mu} .$$

This is given in Table 10.

Time Period	Utilization factor = ρ when		
	s=1	s=2	s=3
8 - 9	0.680	0.340	0.227
9 - 10	0.890	0.445	0.297
10 - 11	1.270	0.635	0.423
11 - 12	1.260	0.630	0.420
12 - 13	1.460	0.730	0.487
13 - 14	1.201	0.600	0.400
14 - 15	1.195	0.598	0.398
15 - 16	1.485	0.593	0.395
16 - 17	1.251	0.626	0.417
17 - 18	0.995	0.498	0.332
18 - 19	1.180	0.590	0.360
19 - 20	0.879	0.439	0.293
20 - 21	0.891	0.446	0.297
21 - 22	0.761	0.380	0.254

TABLE 10. UTILIZATION FACTOR

From Ref. (2), it is suggested that $\rho<0.667$ will yield library service that will not cause excessive delays. From Table 10 it is seen that for single server $\rho>0.667$ for all time periods therefore it will always cause excessive delays. Also, during some of the time periods $\rho>1$ it implies that in case of single server the given length will go on increasing. In case of two servers $\rho<0.667$ except during 12 to 13. Therefore, it is suggested that two servers are sufficient except the period 12 to 13. For period 12 to 13 if there are three servers ρ will decrease to 0.487.

CONCLUSIONS

From the above analysis three servers are necessary during the period 12 to 13 and two servers are necessary during the rest of the library hours. With this policy, the average user waiting time is 1.378 minutes.

It should be noted that data collected for line length was at an interval of fifteen minutes. If this interval is reduced, more accurate mean line lengths could be determined and thus, more accurate ρ. Besides the number of servers required, this analysis also tells us about the total waiting time for each person (including service time).

ACKNOWLEDGEMENTS

The author is grateful to William B. Rouse, Assistant Professor of Engineering Design, for his guidance in understanding the different situations. The author is also indebted to Mrs. Myra Siegenthaler, Head of Circulation Desk, Wessell Library, Tufts University, for her cooperation and suggestions throughout the course of this study.

REFERENCES

1. Fredrick S. Hillier and Gerald J. Liberman. Introduction to Operations Research, Holden-Day, San Francisco, 1967.

2. Philip M. Morse. Library Effectiveness, M.I.T. Press, Cambridge, Mass. 1968.

3. William B. Rouse and Sandra H. Rouse. "Use of a Librarian/Consultant Team to Study Library Operations", College and Research Libraries, Vol. 34, No. 5, Sept. 1973, pp 242-248.

STAFFING THE RESERVE BOOK ROOM

William B. Rouse and Sandra H. Rouse

ABSTRACT

An approach to staffing the Reserve Book Room at Tufts' Wessell Library is discussed. Characteristics of user demand and staff service are presented. Queuing models and dynamic programming are used to determine the allocation of staff man-hours that minimizes average user waiting time.

INTRODUCTION

This paper discusses a study of the Reserve Book Room at Tufts' Wessell Library. Initially, the authors had hoped to evaluate the use of the reserve collection. This would have included usage of materials as a function of discipline, level of the course for which the material was reserved, etc. However, in developing data collection methods, it became evident that the student staff who check-out materials were much too busy to record the necessary data. Thus, it was realized that staffing of the Reserve Book Room would have to be dealt with first.

Weekday operation of the Reserve Book Room between 8:30 AM and 9:30 PM was considered. When this study began, twenty-six student man-hours per day were allocated to this period. Observation easily led one to believe this was often inadequate. Before data collection had begun, the allocation was increased to thirty man-hours. The results of this study show that this increase was justified.

THE RESERVE BOOK ROOM

The Wessell Library Reserve Book Room collection is shelved on closed and open stacks. A professor may request that certain items be placed on closed reserve because he expects this material to be used more frequently by the students in his course. Limiting the loan period increases the probability of success that each student will experience in requesting the item.

Wessell Library policy is that generally all closed reserve items must be used in the Library and can only be signed out after 9:00 PM, and returned by 9:30 AM, the following morning. The open reserve loan period is determined by the professor and is usually specified as one to seven days. These books may be consulted without assistance from the reserve desk staff.

The total collection size is approximately 15,000 items with an average circulation rate of 400 a day. The room is staffed by a full-time supervisor and assistant, a part-time typist, and approximately twenty-seven part-time students whose main responsibility is to circulate and reshelve the reserve collection.

The operation of main concern is how quickly the reserve circulation staff satisfies a user's request. Routinely, this involves a user requesting a particular item on closed reserve. The circulation attendant locates the item, stamps the check-out

card with the student identification card and files the record at the desk. Or, for example, a user might request to reserve an item for overnight use. The attendant, after some preliminary checking for the status of the item, gives the user an overnight card to fill out which alerts interim users to return the item to the desk by 9:00 PM.

The supervisor is consulted when difficulty arises in fulfilling the requests. Because she usually works near the circulation desk, the supervisor also serves users when the line of users increases to the point that it significantly exceeds the number of attendants. Generally, the assistant works less frequently near the desk and thus, less frequently intervenes in serving users.

In summary, this paper focuses on the following three elements of the reserve circulation operation:

1. Number of servers behind the desk, i.e., students and supervisors;

2. Number of users waiting in line for service and being served;

3. The amount of time it takes to satisfy a user.

DATA COLLECTION

The situation as described in the previous section easily leads to the use of waiting line or queuing models. This requires measurement of the average arrival rate of users, λ, and the average service rate, μ.

Direct measurement of λ would require recording the exact arrival time of each user. This would be very time consuming. Thus, another sampling approach was adopted. The number of people in line (including those being serviced) was recorded every fifteen minutes for two hour periods. The collection periods were fairly uniformly distributed over the day between 8:30 AM and 9:30 PM. The intervals were chosen to correspond with class times at Tufts as this is the way in which student help must be scheduled. Between October 12th and November 15th, data was collected for fifteen periods totaling 151 measurements. Along with the line length measurement, the number of servers, s, were recorded in two categories. The categories were scheduled student servers and supervisory servers.

The service time includes only the time it takes to satisfy a user's request and not the time he may have spent waiting to make his request. The distribution of service times was determined by clocking 157 services between November 9th and 19th. The numbers of servers were recorded in the same two categories.

ANALYSIS

Testing the hypothesis that service rate was affected by the number of people waiting in line, the correlation coefficient of service time and line length was calculated and found to be -0.05. This appears to reject the hypothesis and thus, service rate was assumed to be independent of line length.

Assuming exponentially distributed service times, the average service rate is the reciprocal of the area under the cumulative probability distribution function

P(service time>T). This function is ploted in Figure 1. From this data, it was found that $\mu = 0.921$ customers per minute.

The queuing models discussed by Hillier and Lieberman [1] relate λ and μ to the average line length, L. Line length is defined as the total number of users at the desk, including those currently being serviced. The sampling method employed in this study resulted in measurements of L for the thirteen one hour intervals between 8:30 AM and 9:30 PM. The number of servers, s, varied from one to four during the period of data collection.

Given μ, L, and s, the appropriate model from Hillier and Lieberman was used to calculate λ (assuming Poisson arrivals). For some time intervals, this resulted in four estimates of λ since s varied from one to four within that individual interval. It was necessary to determine a single estimate of λ for each one hour interval since student servers are scheduled in one hour multiples. Assuming steady-state measurements, a single estimate of λ was determined by averaging the four λ's.

$$\lambda = \frac{1}{N}(n_1\lambda_1 + n_2\lambda_2 + n_3\lambda_3 + n_4\lambda_4) \qquad (1)$$

where

λ_i = estimate of λ with s=i,
n_i = number of measurements with s=i,
$N = n_1 + n_2 + n_3 + n_4$.

Using the method described above, λ (in users per minute) was determined for each of the thirteen one-hour intervals between 8:30 AM and 9:30PM. The results are shown in Figure 2.

Given λ and μ, the process is adequately described and personnel can be allocated to the above periods as follows. The procedure used was to allocate personnel so as to minimize average user waiting time, W. Waiting time includes that in the queue and the actual servicing. Dynamic programming [1] was used to minimize

$$W = \frac{1}{\lambda}(\lambda_1 W_1 + \lambda_2 W_2 + \ldots + \lambda_{13} W_{13}) \qquad (2)$$

where λ_i = average arrival rate in ith period,
W_i = average waiting time in ith period,
$\lambda = \lambda_1 + \lambda_2 + \ldots + \lambda_{13}$.

It was assumed that no more than four students could be allocated to a given interval because of the limited space behind the reserve desk.

RESULTS

Figure 3 shows W as a function of man-hours per day, T, invested in the thirteen one-hour intervals. The current allocation is thirty man-hours. Reducing the man-hours to twenty-five, a reduction of one-sixth, increases W by a factor of approximately five. Increasing T by one-sixth reduces W by approximately one-eighth.

The optimal allocation of personnel for several values of T is shown in Table I.

TIME INTERVAL	MAN - HOURS, T 26	28	30	32	34
8:30-9:30	2	2	3	3	3
9:30-10:30	2	2	2	3	3
10:30-11:30	2	2	2	2	2
11:30-12:30	2	2	2	2	3
12:30-1:30	2	2	2	3	3
1:30-2:30	2	3	3	3	3
2:30-3:30	3	3	4	4	4
3:30-4:30	2	2	2	2	3
4:30-5:30	2	2	2	2	2
5:30-6:30	1	2	2	2	2
6:30-7:30	2	2	2	2	2
7:30-8:30	2	2	2	2	2
8:30-9:30	2	2	2	2	2
AVG. WAITING TIME (MIN.)	2.98	1.80	1.65	1.55	1.47

OPTIMAL ALLOCATION OF PERSONNEL

TABLE I

CONCLUSIONS

Table I shows that there is a trade-off between man-hours (dollars) and customer waiting time. If the cost of customer waiting could be put in terms of dollars, perhaps as suggested by Morse [2], the trade-off could then be made. Another approach would be the use of decision analysis in a manner similar to that discussed by Rouse [3]. Unfortunately, time did not allow for an analytical approach to this trade-off. However, Table I indicates that the "best" T is probably in the twenty-eight to thirty-two hour range.

It is important to emphasize that the average waiting times shown in Figure 3 and Table I assume an optimal allocation of man-hours. Other allocations than those indicated in Table I may result in substantially higher average waiting time. For example, if the allocation of twenty-six man-hours was changed from that in Table I to an allocation of two man-hours for each of the thirteen periods, the average waiting time becomes 7.38 minutes. One should remember that 7.38 is an average and some users will experience much longer waiting times. The reason for this dramatic increase should be evident from the demand curve in Figure 2.

This situation is somewhat improved by the fact that the Reserve Book Room

supervisors work at the reserve desk when the queue becomes large. However, it would seem that one would not want to schedule supervisory personnel for regular shifts at the reserve desk. Thus, man-hours should not be decreased below twenty-eight hours.

ACKNOWLEDGEMENTS

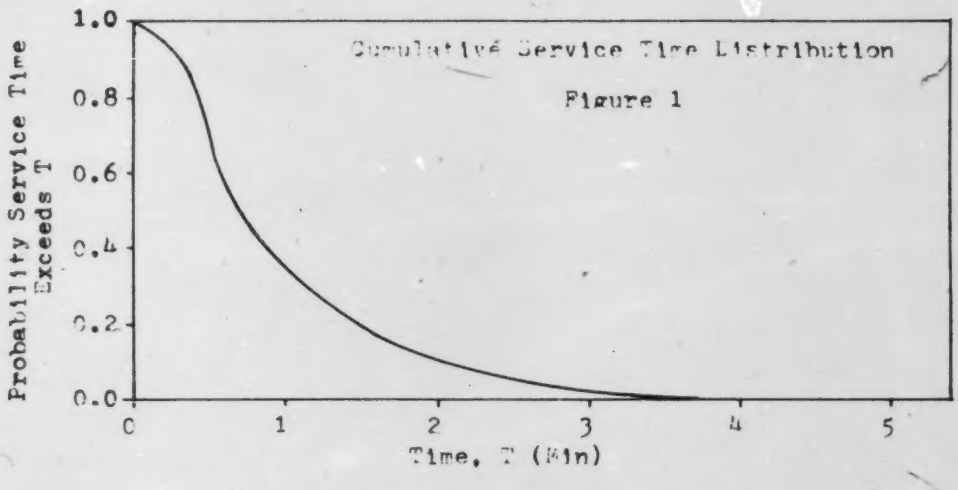
The authors gratefully acknowledge the support and enthusiasm of George Beal, Head of Circulation, and Anne M. Smith, Reserve Book Room Supervisor.

REFERENCES

1. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, Holden-Day, San Francisco, 1967.

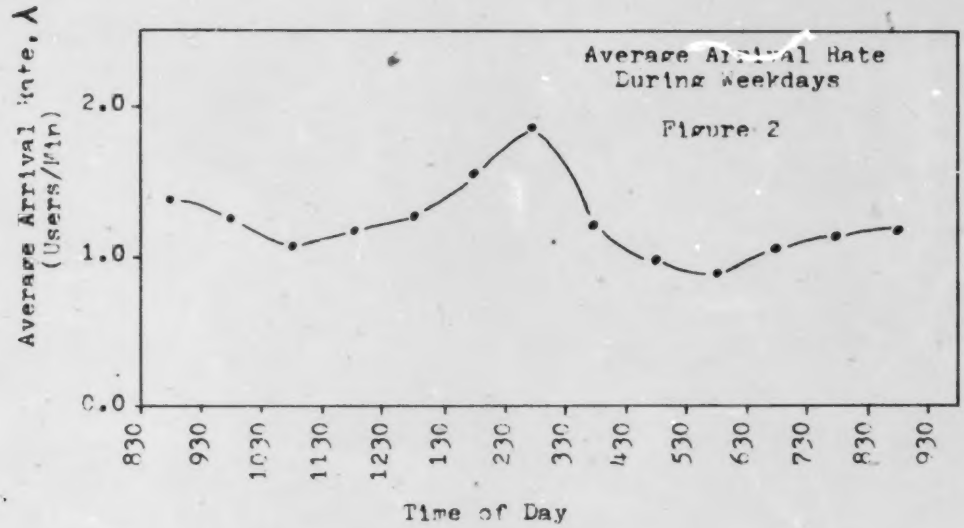
2. P. M. Morse, Library Effectiveness, MIT Press, Cambridge, 1968, pp. 79-82.

3. W. B. Rouse, "Optimal Selection of Acquisition Sources", submitted to the Journal of the American Society for Information Science.



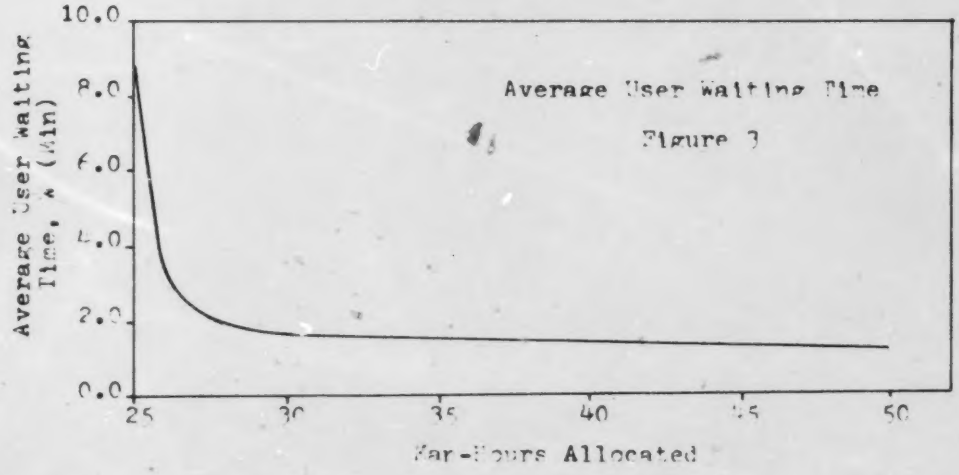
Cumulative Service Time Distribution

Figure 1



Average Arrival Rate During Weekdays

Figure 2



Average User Waiting Time

Figure 3

BOOK SELECTION

Cynthia B. Koster

ABSTRACT:

The concern of this paper is to analyse the present acquisitions policy and to submit proposals that would lead to a rational and balanced building of resource materials in the University Library. Faculty book selection policy is investigated and subjected to statistical tests to determine which practices result in the most effective book selection.

INTRODUCTION

At Tufts, the responsibility for book selection lies primarily with the individual professors in each department. Specific allotments are made to these departments on the basis of the number of undergraduate majors, courses offered, and other criteria concerning the present status of the collection in that area and the importance of the department with respect to the University as a whole. In some departments, ordering is prolific, if not always discriminating, and the allotments are often exceeded. In these cases, book orders are sent back to the particular department, from the library, to establish priorities for purchasing. In other departments, ordering is sparse and without some input by the library, these areas are neglected altogether. Retiring professors, or those leaving for another appointment, if not replaced by another similar specialist, leave collections untended. Due to the increasing scarcity of non-current publications, inattendance to a particular area for a period of years reduces even a once adequate collection to a weak and dated one. In addition, if the original professor emphasized a specific area within a broader field, then left his position at Tufts, there is no reason to expect that his or her replacement will order books complementing the existing collection. This leads to uneven development even within a narrow field.

Even if a particular professor has a great deal of interest in book selection, the shear physical effort of screening dozens of publishers' lists, special area reviews, current publications' lists, and those for out-of-print materials requires more time than that available to most professors who frequently have involvements outside the general research and course requirements. Often, though professors receive a great deal of literature and reviews, they do not have ready accessibility to the vast number of bibliographic materials available to the University Library staff.

As a result of the inadequacy of faculty selection, at least total dependance on such, many libraries in the United States have begun shifting at least the major portion of responsibility over to professional librarians in the university library. Such a system has existed in many German universities for over a century and although their situation is somewhat different than that of

most of the American universities, the major advantages to this particular means of building a university library appear to also apply to many of the American university libraries. Instead of having major responsibility for book selection in the library, where it appears to reside as far as administration, philosophy, and rationality, it is with the faculty who have little accountability. There is also an apparent lack of flexibility due to the fact that most of the total allocation for purchasing resource materials for the library is in the hands of the individual departments. This would tend to restrict large purchasing, by the library itself or by an individual department. Since most professors order only in specific areas they are interested in, the peripheral areas such as socio-economics or political anthropology are neglected. Unless there is input by the library staff, which cannot be expected, serious gaps in the collection might arise.

Overall coordination promotes an even and balanced growth in the areas necessary for support of the library's clientel- its students, both undergraduate and graduate, and the professors and staff. The University Library at Tufts, hopefully would reach the point where it could anticipate these needs. Eventually, if the Library is to have continued balanced growth, this shift away from faculty book ordering to selection by professional librarians must take place. Rationally, book selection, and the appropriations for purchasing such material belong within the Library. Faculty input should remain a significant part of selection as a whole but should not be the dominant force.

APPROACH

A questionnaire (shown below) was distributed to the faculty concerning book selection in order to determine the criteria used in ordering within the departments. Questions were posed about the existence of planning, both long and short-range, the bibliographic materials consulted, possible support for coordinated purchasing within the consortium, and specifically, the number of books and periodicals ordered by the individual professors each year. Information concerning length of time at Tufts, status within the department and department were also requested. The results were tested for correlation, cummulative frequency distributions were tabulated and tested for their statistical significance.

In addition, the three schools involved with Tufts University in the consortium were investigated as per their book selection policies.

RESULTS

Correlations were set up between all variables and it was found that for all but a few variable pairs, the correlation was negligible. The pairs that had some correlation were all statistically significant but the actual correlation was not particularly significant, generally explaining only a small portion of the variance between the two variables.

Cummulative frequency distributions for seven variables were tested for statistical significance and it was found that those

QUESTIONNAIRE

1. How many books, on the average, do you request for order in a year's time? Periodicals? Other (please specify)? To your knowledge, are all of these materials purchased and if not why?

2. Name some of the materials you use (book reviews, publishers' lists) in order to select books/ and or periodicals.

3. Are you responsible, within your department, for one particular area of study? If not, do you coordinate your selection with the other professor or professors who share your field of interest?

4. Do you or a student on work/study check all orders against the card catalogue prior to submitting your list to the library?

5. Is there any short range planning, per year, for the particular development of one area within your department? If so, how is this determined?

6. Is there any long range planning within the department to build a collection of basic materials only or is there some general plan for development, to the "research level" in a particular field?

7. Do you feel that the selection of books belongs primarily within the separate departments, if so why?

8. Would you support a shift of selection from individual professors and departments to a professional bibliographer in the Library, if not why?

9. Due to money constraints on the individual departments, is there any internal division of allocations between areas of study or is it first-come, first-served?

10. Is there any attempt to categorize the requested books according to importance prior to submitting the list to the Library? (eg. "top priority", "necessary if money available") If there is no such system, would you support the institution of one?

11. Do you have any specific suggestions as to how book selection can be improved?

12. Tufts University has joined three of the surrounding universities in cross-registration and there is limited coordination between the various libraries (including Boston Public Library). Would you advocate joint purchasing of particularly esoteric materials between these libraries-or intensive development in a particular area of study at one of the libraries with other libraries contributing a portion of the cost?

13. For those departments concerned, is there any coordination, at least at the level of checking available materials, with the Fletcher School Library?

14. When a new program/course is added, is there any study of the present collection in this area, or a specific list of necessary materials submitted to the Library prior to the program's inception?

professors responsible for a specific area of study within his or her department ordered significantly more books than those not responsible, in a ratio of about two to one. (t-test, 0.025 level) Results showed that those professors either having their own short-range planning or were members of a department having such planning also ordered significantly more books than those professors lacking all short-range planning.(t-test, 0.005 level) Assuming that those responding to the questionnaire are more interested in book selection than those not responding, it would be expected that both the results of responsibility in an area and short-range planning would be even more significant if a larger sampling was obtained.

The results of the investigation at the other schools participating in the consortium tend to substantiate the assumptions that faculty input is generally not adequate for building a balanced collection. Both Boston University and Boston College have book-selection policies requiring professional acquisitions librarians. It was felt at these schools that faculty input was not adequate and was uncoordinated with respect to the total collection. The shift to professionals has been in the last four years and has been found to be superior to the previous policies of faculty selection. Although there is continued faculty input, it is coordinated closely and in consultation with the librarian responsible for their field. In both cases, faculty opposition has not been a problem though at Boston College there is a continuing lack of interest in library selection policies which serves to limit faculty input. Brandeis University has a selection policy similar to that at Tufts University. Their policy appears to be based on a lack of money available for hiring an adequate staff for an acquisitions department with the responsibilities of those at Boston University and Boston College. Also, there seems to be general satisfaction, on the part of the Director of the Library, with the quantity and quality of faculty book selection. Though there is no specific plan for any future shift to professionals, the feeling is that there would be little faculty opposition if such a shift occurred, providing that professors' orders were still given high priority for their selection.

CONCLUSIONS

Due to the lack of correlation between variables such as number of books ordered and long-range planning or responsiblity and policies for adding new programs, it appears that there is little or no policy for book selection among a large percentage of the faculty. Though they are definitely opposed to a shift to library responsibility for acquisitions (64.7%), there does not appear to be any sort of continual coordination either by the individual professor or in most of the departments over a long period of time. Unless such planning is introduced, allowing continued faculty control over book selection will serve to promote uneven, unplanned acquisitions. At this point, faculty selection is not a function of their status (tenured or non-tenured), years at Tufts, or the size of their particular department. Its basis appears to be significantly

related to responsibility and short-range planning. It is proposed that since those professors with specific responsibility in an area within their respective departments do order significantly more books than those without such responsibility, specific areas for ordering should be determined and assigned to each professor within all departments. This would increase accountability and perhaps the overall amount of books ordered. Each department should also insist on some planning-flexible yet with specific direction- of each professor. This should be articulated to all members of the department to increase coordination and comprehensiveness. This individual planning could be incorporated in the basic, long-range goals of the department itself.

Library committees should be set up in each department, one or two professors depending on the size, in order to maintain optimal communication with the Library. It would also enable the department itself to ascertain whether areas are being covered adequately.

Because of the general policy at Tufts University, primary emphasis has been placed on building the undergraduate collection. There should be serious re-evaluation of the existing graduate programs, specifically the doctoral programs. If the policy is going to support undergraduate needs first, there should be a similar emphasis within the departments themselves. Certainly if the cost of building up an adequate set of research materials for a graduate program is explicit ly considered as a cost of that program, decisions could be made with respect to the existing programs (and any new ones proposed) in a realistic manner.

Concerning the long-range goals of the University Library, there should be serious discussion among those elements most concerned- the administration, the faculty, and the Library. The pattern set up by the top fifty colleges has indicated that Tufts will have to re-consider its present acquisitions' policy in the future. If there is going to be substantially more support for graduate programs than there has been in the past, a shift to professional librarians with responsibility for book selection and general collection building must take place. If the policies regarding the Library's growth are going to remain primarily concerned with development of an undergraduate collection, then the changes indicated within the departments and between the departments and the Library should be adequate.

Though the sample size is not great, it is felt that the conclusions are supportable if the assumption is made that the more active professors responded to the questionnaire. Of the 21 departments that returned at least one questionnaire, there are about 250 full-time professors (instructors were not included in this sampling), resulting in a sample equivalent to about 1/5 of the total professors in these departments. In some departments, five professors returned questionnaires and thus represented from 1/5 to 1/3 of the total in the department. Though the statistical evidence produced only two significant areas affecting book selection, it is felt that it does represent a portion of the faculty and thus reflects at least several of the important attitudes towards book selection.

ACKNOWLEDGEMENTS

The aid extended by the Library's Director, Mr. Komidar, the acquisitions librarian, Mr. Jones, those professors personally helping in setting up the questionnaire, and the acquisitions librarians at Boston University, Boston College and Brandeis University, the Director of the Library at Brandeis all contributed to the success of this study and provided, in most cases, information otherwise inaccessible.

REFERENCES

Danton, J. Periam, Book Selection and Collections: A Comparison of German and American University Libraries, New York, 1963, Chapter III,IV.

Acquisitions Policies and Interests of the UCLA Library: A Panel Discussion by Members of the University Administration, Faculty and Library Staff, November 23, 1953. Occaisional Papers #1 University of California Library, Los Angeles, 1954.

A STUDY OF THE UTILITY OF ENGINEERING SCIENCE PERIODICALS

Joseph Codi
&
Elaine Mroz

ABSTRACT

The purpose of the project was to determine criteria for placing journals into remote storage in order to provide space for the accommodation of new journals in Tufts Lufkin Engineering Library. Journal usage was studied as a function of type of journal, and of age of a particular volume at the time of usage. The Bradford Distribution was used as a method of correlating the data with results of previous researchers.

INTRODUCTION

Lufkin Library is the largest branch of the Tufts University Libraries. In Lufkin, volumes pertaining to the Engineering Sciences and in some cases, to Applied Mathematics and Physics are housed. The Journal Collection consists of roughly 400 titles, some of which date from the late nineteenth century. As plans are under way to combine the Engineering Collection with the entire Mathematics and Physics Collection in the space which is currently filled by Engineering volumes, it is obvious that steps must be taken to provide space for the most frequently used volumes.

For the purposes of the project the journals were classified into two categories according to emphasis. Those journals which were primarily academically oriented, dealing with articles of a theoretical or research nature were classified as "scholarly." Journals which were commercially oriented, pertaining to applications and techniques, and dealing with the theoretical aspects of a problem on a more superficial basis were designated as "trade" journals. These classification were determined by inspection of recent volumes. It was felt that the utility of a journal may decrease differently with time dependent upon its characteristic. Of the journals for which data was collected, 68% were of a scholarly designation, and 32% were considered trade journals.

Library journal usage also was classified into two categories. The first category is that of charge-outs. In this case, a journal is removed from the library for a span of up to two weeks in the case of students, or up to a month for faculty. There is, however, a liberal working renewal policy in which books are charged-out for an indefinite length of time subject to call-backs. This option seems to be most widely used by graduate students working on theses or research projects. The charge-out date is not recorded; however, the due date, which in this case is totally analagous is recorded generally in two spots. The due date is stamped on both the circulation card which is filed at the circulation desk while the volume is out of the library, and on the inside back cover of the volume. In general, if the number of usages were so excessive as to require more than one card, the record of prior usages could be found by checking the back cover.

The second category of usage is the in-house usages. In this case a journal may be taken off the shelf for quick reference or to make a copy of a particular page or article. Even more significantly, the in-house use may be for the purpose of researching a project or paper. In this case, the in-house usage is very nearly equivalent in utility to a charge-out usage.

A further natural distinction to be made is between bound and unbound periodicals. As already stated, bound volumes provide a ready and accurate record of usages and dates. However, unbound journals present a special problem in that there is no permanent charge-out

record. It appeared that unbound journals were rarely ever unstacked. However, if a charge-out does occur, the usage is temporarily recorded on a pre-printed slip of paper at the circulation desk. The due date may be stamped on the inside back cover, or a slip with the due date may be paper-clipped to the journal. In both instances, the record is neither permanent nor reliable.

Although some research has been done into the study of obsolescence of scientific journals, one of the foremost researcher, B.C. Brookes, emphasizes the need for recognition of the uniqueness of each library's situation (1). Usage in a university library will be different from usage in a public library or usage in a research firm. However, there may be different user needs and habits between universities. In addition, even within a university there are at least two different classes of users: faculty, who are often contributors to the literature; and students whose journal usage may be viewed as a means of ultimately becoming a user with characteristics similar to the faculty. Thus, although we can look to the work of previous researchers for guidance, we must depend on our own results for our conclusions.

In 1948, S.C. Bradford (2) proposed a model by which he saw a means of dividing periodical literature into zones of usefulness. His law states that if periodicals are arranged according to the number of articles that each contains on a given topic, then the total periodical collection can be divided into equal usage zones such that the successive zones will form a geometric progression of $1:n:n^2:n^3:\ldots$, with a nucleus of journals comprising a great percentage of the usages. This principle has subsequently been expanded to consider acquisition and usages as related to a similar pattern of nucleus and progression of journals of a given utility. Perhaps because of the relatively small number of journals studied, the geometric progression did not seem to hold. However, the concepts of a nucleus of most-used journals and of zones of equal usage have proved useful in the data analysis. This phenomena may be viewed from two angles: one from the dimension of age in which we assume the nucleus of uses is around the time of publication of the given volume; the other from the dimension of individual journal, where the nucleus of which journals contribute the most to usage figures must be determined from the collection of data.

It is to be noted that there is an historical usage of periodical scientific literature as well as a purely scientific usage. As a journal of a given year geometrically approaches scientific obsolescence, it may gain somewhat from an historical perspective. Exactly what constitues a scientific usage as opposed to an historical one is difficult, if not impossible to determine. Checking back to an original source may be viewed as either kind. However, for the purposes of this endeavor, only scientific usages were considered significant.

DATA COLLECTION

In many previous studies researchers felt there was a paucity of available data , or a problem with attaining a representative sample. This was not seen to be a problem in this particular instance, as every available bit of data was recorded and compiled.

As previously implied, it was feasible to collect data only for journals which were bound. Although a significant portion of the collection was unbound, we must trust that we are not drastically biasing our results by considering only bound copies. Similarly, we avoided occurrences of historical usages by arbitrarily choosing as a starting point for data collections volumes published in 1950. Thus, 24 years worth of recordable data was transcribed.

Charge-out usages were recorded by noting the journal name, year of publication of the specific volume, and the date of each usage from binding until the present. In effect, the information present on the circulation card was replicated. If a usage occurred in a volume which contained more than one year's publication, the usage was recorded as having occurred in the earliest year. In this way we give the user the benefit of the doubt in any age-usage analysis. Renewals were recorded as separate usages, but only to a maximum of two renewals (or, equivalently, a total of three usages) for any one user at one time. This was arbitrarily chosen to minimize the difference between a "long" charge-out and one in which the volume is renewed periodically but perhaps not actually used. Subsequent to the recording of data, the journals were checked to determine their content as being trade or scholarly.

In-house usages were recorded by relying on the good-will of the library patrons. A sign explaining the project was posted in the stacks, along with notes in the desks requesting that any journal used during the visit to the library not be reshelved. Daily trips to the library were made at which time each journal use was recorded along with the date of the volume and the date of the usage. The volumes were then reshelved to lessen the chance of a journal being used twice but recorded only once. This data was collected over a period of two months. Unfortunately, due to time constraints, the time period was mid-semester, presumably a low point in in-house usage.

DATA ANALYSIS

In analyzing the data, it was necessary to keep in mind two separate methods of approach. The first objective is to determine which journals comprise the nucleus of most used books, after Bradford's proposal, and to determine in which zone any given journal falls. The second objective is to determine how journal usage decreases with time.

In determing the Bradford distribution the journals were first separated by the scholarly-trade criterion. The scholarly journals, comprising over 2/3 of the titles were arranged in descending order according to the total number of usages of the journal over the 24 year period. The journals were then grouped into 6 zones, each corresponding to roughly 200 usages. The results of this grouping is shown in Table 1. As can be seen, the first three zones consist of only 10 journal titles. Thus, 7% of the scholarly journal titles account for 50% of the usages since 1950. A similar arrangement was made of the trade journals, except that in this case 7 zones corresponding to 85 uses each were assumed. From Table 2 we see that the eight journals which comprise the top 5 zones account for 71% of all trade journal use.

It is also interesting to note that 35% of the scholarly journals, and 33%of the trade journals were never charged-out over the 24 years which were studied in this project. These journals are listed in Table 3.

We have, in this analysis neglected the in-house usage. Are the journals referred to while in the library the same as those which are frequently charged-out? Strangely enough, this did not prove to be the case. In both trade and scholarly journals, there appeared to be an unfair balance toward usage in the rarely charged-out zones. There is no apparent explanation for this, except that there may have been a common reason for not using these journals outside the library, and for using them while in the library. Nonetheless, this phenomenon must not be over-looked.

In determining journal usage as a function of age, the distinction was still maintained between trade and scholarly journals. However, it was found that the difference in usage was not very significant, with

TABLE 1: Usage Zones for Scholarly Journals
(number listed is number of times used since 1950)

Zone 1	
Water Poll. Cont. Fed. J.	125
Sewage & Industrial Wastes	85
Zone 2	
ASCE Transactions	84
Inst. of Radio Eng. Proc.	59
Sanitary Eng'ng J., ASCE	62
Zone 3	
American Concrete J.	35
Am. Water Wrks J.	49
Engineering News Record	36
IEEE-Microwave Thry & Tech.	54
J. of Fluid Mechanics	42
Zone 4	
Archives of Envmntl Health	24
Aviation Wk & Spce Tech.	24
Bell System Tech. J.	25
Electrical Engineering	17
Geotechnique	17
IEEE Proceedings	31
Inst. of Metals J.	21
J. of Appl. Mech.	18
Soil Mech & Fndtns,ASCE	22
Zone 5	
Air Poll. Cont. Assoc. J.	11
Applied Scientific Rsch.	9
Am. Soc. of Mech Eng. J.	9
Atmospheric Engvironment	8
J. of Boston Soc. of Civ. Eng.	15
J. of Heat Transfer	9
J. of Sound Vibration	10
N.E. Water Wrks J.	13
Solar Energy	8
Struct. Div. J., ASCE	10
Traffic Quarterly	14
Waterways& Harbors, ASCE	8
Water Resources Rsch.	13
Zone 6	
Aeronautical J.	1
Am. Ind. Hygeine Assc.	1
ARS	1
ASCE Power Div.	1
ASCE Transportation	1
ASCE Surveying & Mapping	1
Am. Soc. of Mth Statistics	1
ACM Communications	1
Automation & Remote Control	3
AIAA Journal	6
British J. of Appl. Phys.	3
Bulletin of JSME	2
Eng. Mech. Div. ASCE	6
Exprmntl Mechanics	3
Electronic Technology	2
General Motors Eng. J.	3
High Spd. Grnd Transptn J.	2
IEEE-Electronic Devices	6
IEEE-Computers	4

Zone 6 (cont.)	
IEEE-Computers	4
IEEE-Nuclear Science	4
IEEE-Antennas & Propgtn	3
IEEE-Information Theory	3
IEEE-Circuit Thry	2
IEEE-Communication Tech.	2
IEEE Power Apparatus & Systems	2
IEEE-Aerospace	1
IEEE-Audio & Electrical Acoustics	1
IEEE-Brdcst & TV Rcvrs	1
IEEE-Geoscience Electronics	1
IEEE Instrumntn & Meas	1
IEEE-Magnetics	1
IEEE-Sonics & Ultrasonics	1
IEEE Systems & Cybernetics	1
Int. J. of Eng. Sci.	1
Int. J. of Non-Linear Mech	1
Int. J. of Sci & Tech.	1
Int J. of Mech. Sciences	7
I.B.M. Journal	8
Irrigation & Drainage, ASCE	4
Int. J. of Heat & Mass Transfer	3
J.of Inst. of Electrical Eng.	3
Int. J. of Solids & Struc.	2
International Science & Tech.	1
J. of Applied Mth & Mech.	1
J. of Basic Engineering	7
J. of Materials	7
J. of Eng. for Industry	5
J. of Mech. Eng'ng Sciences	4
J. of of Inst. of Elec. Engnrs	3
J. of Mech & Phys. of Solids	2
J. of Mth & Physics	1
J. of Composite Materials	1
J. de Mechanique	1
J. of Aircraft	1
J. of Eng. Science & Tech.	1
Machinery	3
Machine Design	1
Materials Science & Eng'ng	1
Metallurgical Soc. of AIME Trnsctns	1
Methods of Computation	2
Materials Research & Stnds	2
Public Roads	2
Solid State Electronics	5
Soil Mechanics & Fndtn Eng.	2
Quarterly J. of Mech. & Appl. Mth	1
Quarterly of Appl. Mth	1
SIAM Review	1
Nuclear Safety	1
Nuclear Engineering Design	1

trade journals reaching obsolescence slightly sooner than do the scholarly. As can be seen from the graphs in Fig. 1, maximum usage occurs 2-3 years after publication and then begins a steady decline. The concept of half-life is useful in determining the rate of obsolescence. Half-life is the term used to denote the number of years in which half of the total number of remaining usages will occur. In other words, if a journal is to have a total of 50 uses, 25 of these will occur during the first half-life, 12 will occur during the second, 6 in the third, until the no-usage state is asymptotically approached. There appeared to be a well-defined half-life of 3 years for trade journals. The value for scholarly journals was not so easily determined. 50% of the total usages for scholarly journals was reached within 4½ years. However, the obsolescence accelerated somewhat, with 80% of the usages having occurred after 9 years, or 2 half-lives. This rapid acceleration continues for scholarly journals, so that by the end of 3 half-lives (13½ years), 94% of the usages have occurred, whereas in 3 of the trade journal half-lives, only 87% of the uses occurred. In terms of real years, which of necessity is the measure which will be used, it is found that trade journals reach their maximum usage sooner, and drop more quickly to obsolescence than do scholarly journals. For example, after 12 years, 91% of the scholarly usage has occurred, as opposed to 95% of the trade usage. After 15 years, 96% of the scholarly usage has occurred, and 99% of the trade charge-out usage. Once again, it is important not to neglect in-house usage. It was found that 94% of the in-library usages were volumes published since 1959, or in other words, 94% of the usages were of volumes less than 15 years of age.

CONCLUSION

In final analysis, it appears that the decision of when to remove journals from open circulation is a matter of choice for the library staff, based on the data now available. It appears to us that "retiring" journals 15 years subsequent to publication is certainly a reasonable policy, as it provides for roughly 97% of the usage. However, it would also seem reasonable to retain in the library all volumes of the journals which fall in the top 4 zones in the trade category, and the top 3 zones in the scholarly division. Thus, the 16 most frequently used journals would be available at all times. The only conflict of this policy with the data collected would be in the strange zoning of the in-house usages. However, it is felt that because such a large percentage of even the in-house uses occurred when the journals were less than five years old, retaining 15 years of volumes will cover all but a very small portion of desired uses.

It is important to note the possible pit-falls in these recommendations. Firstly, we have completely discounted "historical" usage on the assumption that it seems a small sacrifice to make in terms of providing more space for current literature. There may be those who disagree with this supposition. We were unable to collect data for unbound volumes, and their usage pattern is only assumed to be similar to that of bound volumes. Thirdly, it is important not to generalize the results of this survey to any other situation. For instance usage of math and physics journals may possibly be of a different nature than that of engineering journals. Finally, there is a need for the periodic check of the validity of the results. A journal may at this time be in a low usage zone because it has just recently been subscribed to by the library. In fifteen years it may have become so popular as to move into a top zone. Similarly, new interests in different engineering topics may appear in the following years. For instance, as air and water pollution journals have become popular in the past six or seven years, journals dealing with energy problems will almost certainly come

into fashion in the next two to three years. Thus, it will be important to watch closely the behavior of journal users to keep the library policy in accord with user demands. It would seem advisable to keep current data on disappointed users by asking them to indicate whether they were unable to use a journal because it had been placed in storage. In this way, any inconsistencies between policy and user needs can be quickly recognized and rectified. In addition, we recommend a continuing study of in-house usages to see whether the trends which were apparent from our small amount of data are valid.

REFERENCES

(1) Brookes, B.C., "The Growth, Utility, and Obsolescence of Scientific Periodical Literature." Journal of Documentation 26(Dec.'70): 283-94

(2) Bradford, S.C. Documentation. London:Lockwood, 1948

Other references:

Brookes, B.C. "Bradford's Law and the Bibliography of Science" Nature, Dec. 6, 1969, pp.953-56

Goffman, W. and Morris, T.G. "Bradford's Law and Library Acquisitions" Nature, June 6, 1970, pp. 922-3

Line, M.B. "The Half-Life of Periodical Literature: Apparent and Real Obsolescence" Journal of Documentation 26 (March 1970): 46-54

TABLE 2: Usage Zones for Trade Journals
(number listed is number of times used since 1950)

Zone 1	
American City	73
Zone 2	
Electronics	71
Zone 3	
Civil Engineering	42
Water & Sewage Wks.	46
Zone 4	
Engineering	40
Public Works	45
Zone 5	
Machine Design	31
Progressive Architecture	48
Zone 6	
Illuminating Engineer	9
J. of Franklin Inst.	12
Matrls. in Eng. Design	11
Nucleonics	9
Power	13
Royal Aeronautical Soc.	9
Water Wastes & Eng'ng	19
Zone 7	
Air Cond. Htng & Ventlng	1
Aerospace Engineering	1
American Machinist	6
ASHRAE	1
Automotive Industries	2
Consulting Engineer	2
Control Engineering	7
Electrical World	5
Electronic Design	1
Zone 7 (cont.)	
Industrial Design	7
Industrial Research	2
Industrial Water Eng'ng	4
Machinery	3
Mechanical Engineering	3
Metal Progress	1
Power Plant Engineering	3
Prestressed concrete Ins.	1
Product Engineering	8
Q.S.T.	1
Railway Age	1
Roads & Streets	1
S.A.E.	7
Structural Engineer	6
Traffic Quarterly	1
Wastes Engineering	2
Water Works Engineering	5
World Oil	6

TABLE 3: JOURNALS WITH NO RECORDED USAGES

Scholarly

Acta Mechanica
Acustica
Aeronautical Quarterly
Am. Soc for Eng'ng Education
Electronics Letters
Heat Transfer
High Frequ. Tech & Electr
Hygeine & Sanitation
IEEE-Component Parts
IEEE-Broadcasting
IEEE-Education
IEEE- Electromag. Comp.
IEEE-Industry & General Appl.
IEEE-Ind. Electrncs & Cntrl. Inst.
IEEE-Prod. Eng'ng & Prdctn
IEEE-Reliability
IEEE-Solid State Circuits
Int. Dig. of Health Leg.
Ingenieur
Ingenieur Archive
Inst. of M.E. Automotive Div.
Int. J of Numerical Mthds. in Eng.
J. of Biomechanics
J. of Engineering Graphics
J. of Engineering for Power
J. of Lubrication
J. of Materials
J. of Motion Pict. & T.V.
J. of Nuclear Physics
J. of Physics
J. of Research (Eng. & Inst)
J. of Strain Analysis
J. of Spacecrft & Rckts
Metals Science Journal
Med & Bio. Eng.
Mettallurgical Trnsactns
Nuclear Science & Eng.
Power Reactor Tech.
Pyrodynamics
Scripta Metallurgica
SIAM J. of Appl. Math
SIAM J. of Numerical Analysis
Soviet Elect. Eng.
Soviet Radio & Eng.
Staub
Vacuum
Zeitschrift fur Ange. Math. und Mech.

Trade

Aerospace
Air Engineering
American Aviation
Aeroplane
Datamation
Desalinization
Electronics & Power
Engineers Digest
Factory Mngmnt & Maintenance
Factory
Graphic Science
Heating Piping & Air Cond.
Industrial Electronics
Inst. of Metals Jrn.
Iron Age
Industrial Electronics
J. of Research(Radio Science)
Metals & Materials
Modern Manufacturing
Modern Plastics
Metal Finishing
Mnfctng Eng. & Mngmt
Problem of WFO Transmission
Public Power
Petroleum Refiner
Radio & Electronic Eng'ng
Radio Science
Reaction Fuel Proc. Tech.
Reactor Sci. & Tech.
Revue de Metallurgie
Rubber Chm & Tech.

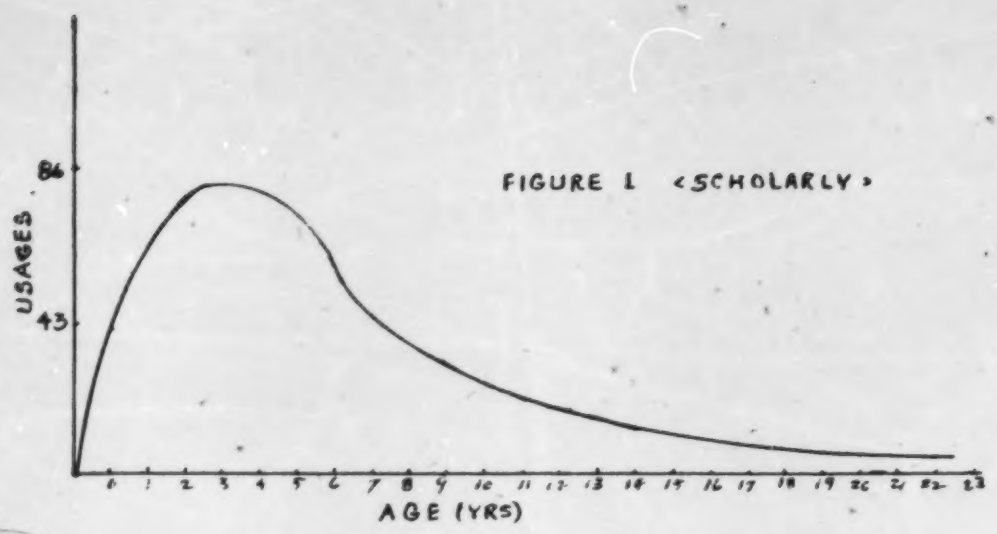


FIGURE 1 <SCHOLARLY>

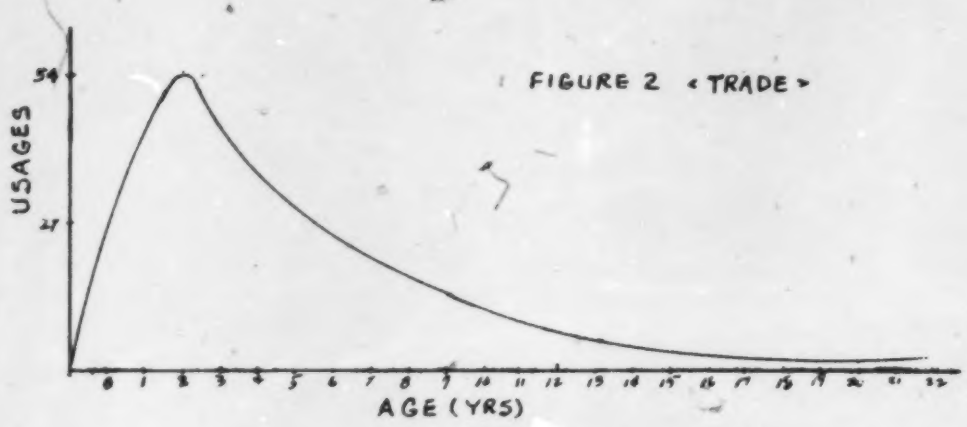


FIGURE 2 <TRADE>

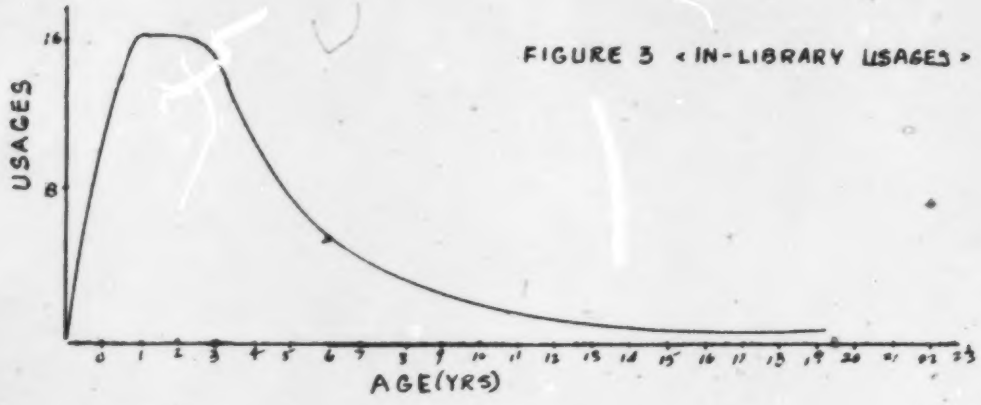


FIGURE 3 <IN-LIBRARY USAGES>

OPTIMAL TRACING PROCEDURES by
John Archer Bly

ABSTRACT

This paper concerns methods of evaluation of library tracing systems, using statistical computer programs and system simulation. It suggests an effective use of cross-tabulation of data in order to find relationships and possible areas of improvement in staff and user searching procedures. It investigates how the spacing and the number of traces affect user and staff costs in order to generate optimal tracing policies and possible educative programs to alleviate such costs.

INTRODUCTION

How effective are present tracing policies; do they minimize user and staff costs? The method of analysis used to answer such questions is quantitative and stresses the technical aid of a computer. Since data is readily available on library tracing systems, in that one need only save trace cards, computerized data analysis is particularly suited for this subject. The programs used are simple and can be mastered by those with only a passing knowledge of Basic or Fortran. Any library wishing to implement the techniques illustrated, need only ask a local student or computer facility to run its data through a system such as the DEC 10 at Tufts University. In doing so it will obtain an evaluation of its system's tracing characteristics, the number of traces which should be made, and the optimal spacing between such traces.

At Tufts any user can ask to have a trace made on a book. The traces average the first, fifth, and ninth weeks during which time such a user must wait until the trace is successful, an average of four weeks, or until the ninth week when the book is declared missing.* The number of books being traced times the number of weeks that they are out of circulation is defined as book-weeks lost. Book-weeks lost are a cost to the user and are considered as a value to be minimized. The proposed methods attack the problem of minimization by simulating the effects that different tracing policies have on book-weeks lost, and by determining what areas contribute an over-proportional amount of book-weeks lost.

The body of the paper is divided into those steps that would be necessary to implement the approach to trace evaluation advanced. It begins with data collection.

DATA COLLECTION

Statistically, the more sample data the better; as long as no major changes have been made on the tracing system, records going

---

*Data quoted in the first half of the paper results from several statistical computer studies made by the author on the Tufts University tracing system.

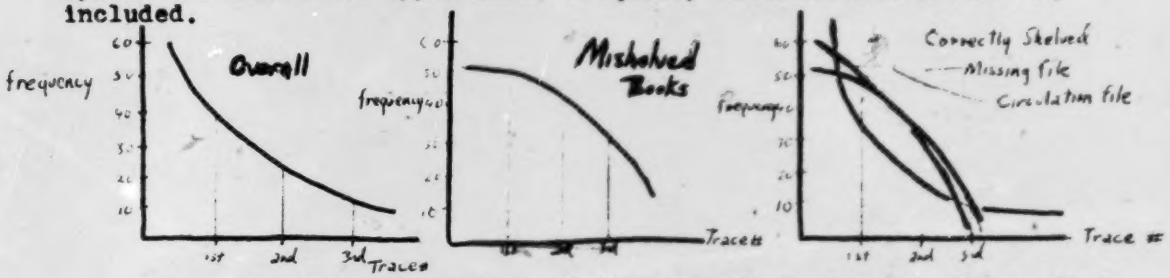
back one or two years should give a statistically accurate analysis. On the other hand if only two or three months are available, a good description of the tracing system can still be obtained, if the data is fairly consistent. Each trace report should contain information as to where the book was found (ie. the circulation file, the missing file, the correct location in the stacks, misshelved by x number of books, never found, etc.), the time elapsed before the book was found, the trace number on which the book was found (ie. the first, second, or third etc.), whether or not the book is usually located in a special location, the length of the call number, the discipline of the book, and any other pertinent information that might affect tracing policy. Leaving out any of these tracing variables infers a lessening of the possible number of cross-tabulations, and consequently a lower scope of evaluation. In particular, the time elapsed before the book was found, and the trace number on which the book was found are necessary for nearly all the techniques used in this paper.

S.P.S.S. EVALUATION

Having typed the data in convenient variable formats, the system is ready to be evaluated. Calling a statistical package, such as the Statistical Package for the Social Sciences (S.P.S.S.), at the Tufts University Computer Center, one asks that the relative frequencies of the variables mentioned in the last section be calculated, so as to procure a general overview of what is happening in the tracing system. This gives an idea of the relative importance of the different tracing areas, the effect that time has on the sucesss of a trace, and the possible lack of data points for any of the variables. Likely results are that one finds a large probability of success for books found in their correct locations, and a comparitively small one for books located through the missing and reserve files. Any deviation from expected norms should reveal problem areas and, perhaps indicate possible solutions. For example, if a user asks to have a trace made on a book, one expects staff to check the files nearby in order to try to locate the book, and thereby avert the necessity of instigating a trace. If one finds a larger than normal expected relative fraquency, such as the relatively large frequency found in the missing file at Tufts University, one questions why and searches for ways to reduce this figure. Likewise, if one finds that the relative frequency of books found does not decrease with time or trace number, or if it varies in any peculiar way it should questioned, understood, and hopefully improved.

To engender an improved understanding of how the frequency of successful traces does vary with respect to time and trace number, one can obtain a pictoral grasp of the situation by asking the statistical package to plot some histograms of the time variables. A histogram is an actual physical representation of the distribution of relative frequencies. It not only aids in the evaluation of the probability distribution of the different areas in which the book was found, but it will also help to choose the probalistic tracing function with respect to time, when it becomes necessary to simulate

the effects that different tracing policies have on the tracing system considered. The following are examples of histograms calculated from cross-tabulated data on the Tufts University tracing system for which the approximate frequency distribution curves are included.



What determines the nature of these curves? One expects to find a smaller percent chance of finding a book as time goes on, thus implying the curve should be downward sloping. The general curve for all books is concave up. It crosses the y axis (percent of missing books found) implying a certain percent are found immediately, and then with an increasing slope the curve eventually becomes asymptotic to the time axis, implying that a percent, albeit very small, will crop after a long number of weeks have passed. Concave upwards seems to be an expected rate from student ielinquence; some students just don't get around to returning books until after a good amount of time goes by - sometimes putting the book directly into the stacks to avoid paying a fine. Curves concave downwards, eg. the missing file, misshelved books, and to a lesser extent, the circulation file, seem to be related to the internal characteristics of the areas involved.

For example, books reshelved in the wrong locations. Here there is a very strong concavity nearly as many books found in second trace as the first. This statistic sharply contrasts the overall average. We look internally for the case and find (bolstered by contributing statistics) that the high percent found on the second try was most likely due to having missed a higher than normal percent of these books on the first trace. If these books had been shelved in their correct locations a much higher percentage of them would have been found on the first trace and a lower percentage on the second trace. The concavity to the origin means that books are returned to the shelf, on the average, later than usual - thus adversely affecting book-weeks lost. Comparing the mean tracing time for misshelved and correctly shelved books, one finds an average of 3.05 and 1.86 weeks respectively, which implees over a one week mean difference. Considering that misplaced books make up about fourteen percent of all traced books, this amounts to a substantial number of book-weeks lost.

It is possible to look at these areas with a different statistic in mind, that is the percent of all books located in an area with respect to the other areas over time. In the study done for Tufts, the missing file illustrates such a usage. If one looks in the missing file on the first trace it should not be necessary to look there on later traces, yet this area produces an increasing percent of all books found with increasing trace number, 12.7%, 18.2%, and 28.6% respectively. Most likely staff underestimates the high proportionality, 15%, of books found there, and thus concentrates on other areas such as the stacks, etc.

Considering slow response rates as preventable, one seeks to find solutions which will tend to normalize the tracing time curves. For misshelved books an effort can be made to improve the tracing rate to correctly shelved standards by searching in such a fashion that books surrounding the correct location (statistics indicate a ten book limit on either side) are perused with an equal rigor to those in the correct location. This takes but a few seconds longer while it obviates the neccessity of later traces, thus saving time (staff and user) on the whole. As to the missing file, it is surmised that staff underestimates the statistical proportionality of tracing successes there, thus leading to a lack of exactness in its use on the first trace. Realizing the small amount of time involved in searching this area and the substantial success rate (15%), efforts to normalize the missing file's return rate through staff education of its relative proportionality would seem worthwhile.

Other interesting statistics include the fact that nearly all traces originating on specially-located books were instigated precisely because those books are aarmarked for special locations. Staff and users seem to have abnormally slow success rates with such books. An increasing percent, with respect to time, of books traced, 16%, 21%, and 28%, are specially-located books. Realizing that these books represent 18% of all traces, education to insure improved recognizance would most likely be lucrative.

There exists a slight sluggishness in the circulation file's tracing time curve, attributed to the misfiling of circulation cards. As with books, circulation cards are occasionally misfiled when a student worker is in a rush or when he confuses a long call-number with that of another book.. An occasional inventory bolstered by staff diligence in searching several cards on either side of the card's correct location, should ameliorate the situation.

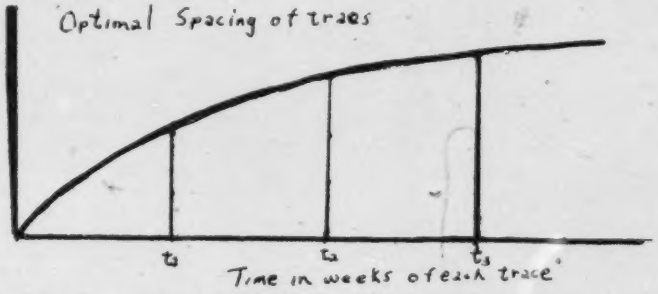
SIMULATION

In order to simulate the effects that different tracing policies have on a tracing system, one must estimate the system's distribution function, fit it, and construct equations which model the different policies. The choice of the parametric form of the probability distribution function, is one of the most important and difficult problems in the evaluation of data. Since such a function will be used as a base from which decisions are made, accurate construction is paramount. In particular it will help us to observe through system simulation, the resultant implications that different tracing policies have on the tracing system, and the number of book-weeks lost. Effectively our goal will be to minimize this number while remaining within various cost constraints.

At Tufts, histograms resulting from the statistical computer package, indicated that the overall tracing distribution function is approximately exponential with respect to time. Therefore, assuming that the probability of finding a book at time t, $f(t) = x_1 \exp(-x_2 t)$, one estimates the x_1 and x_2 which most accurately represents the data, by utilizing one or another cume fitting program available at most computer facilities. Testing the curve with goodness of fit criterion one can obtain an idea of the model's accuracy*, and consequently the validity of subsequent simulation

essays.

In order to observe and eventually minimize the number of book-weeks lost to the user given certain cost restrictions, it is best to construct an equation which calculates book-weeks lost given a probability distribution function and the number of traces to be done. Since, for the Tufts system, the probability distribution function is approximately of the form $f(t)=x_1\exp(x_2t)$ one can calulate the cumulative distribution $f(t)$ by simply integrating. Then $F(t)=(x_1/x_2)(1-\exp(-x_2t))$ which is graphed as follows:



Sample Cumulative Distribution function for a given tracing system.

To calculate the number of book-weeks lost one multiplies the number of books being traced times the time these books have been out of circulation. Suppose, for example, there are traces the first, fifth, and ninth weeks, respectively. After the initial trace the first week, F(1) books have been out for one week giving $F(1)x(1wk.)=F(1)$ book-weeks lost. After the second trace on the fifth week there is a corresponding contribution of $(f(5)-F(1))x5$ book-weeks lost to the system. En total, after the third trace there have been $t_1F(t_1)+t_2(F(t_2)-F(t_1))+t_3(F(t_3)-F(t_2))$ book-weeks lost, where $t_1=1$, $t_2=5$, and $t_3=9$. Any book still unaccounted for after its third trace is classified as missing and, therefore, disregarded.

Given n traces to be made, one can, using arguments similar to the one above, find equations which calculate the number of book-weeks lost for those n traces. Using such methods, the author has written several computer programs which, given the number of traces to be made, prints out that trace sequence which minimizes the number of book-weeks lost; such a trace sequence being the optimal spacing pattern for that number of traces. For example, at Tufts during the period under study,1487 book-weeks of circulation time were lost due to books which were in the process of being traced. Simply changing the spacing of these traces from the present policy of tracing the first, fifth and ninth weeks to a policy in which one traces the second, fifth and ninth weeks one saves more than one hundred book-weeks, giving approximately seven percent reduction. This change is fairly easy to implement requiring only staff education as to the time differences, but it cuts, without increased staff costs, the costs to the user.

Using programs of this sort one can simulate the effects of any policy changes--i.e. by how much will the attendant number of book-weeks rise or fall by adding or subtracting a trace or two

---

*The modeled distribution function for Tufts gave a standard error of one, and mean difference from data of one tenth out of a hundred.

to a given trace system? By how much will the trace system gain or lose by moving towards or away from any one optimal tracing sequence? Such questions are important for any library and should not, consequently be overlooked.

One of the first lessons of operations research is not to rely solely on one's intuition. Therefore one develops some form of cost-benifit analysis. Given an idea of the probability of finding the book on the nth trace, the general cost of each book (including processing and cataloging), and the cost of staff time, one need only estimate the time necessary to search in each area to set up the following cost-benefit criterion:

Let p_n=the probability of finding the book on the nth trace. Let V=the value of the book, including processing and cataloging and let C=cost of search=$W_s x T_s$, where T_s=the staff time necessary to search, and W_s=the staff wage per unit time. To make the searches cost-wise valuable the expected value of these searches should be greater than zero. If not, one is spending more on looking for the book than it is worth. $0<E(\text{value of search})=p_nV-C$, or $p_n>C/V$. Therefore one only traces in an area as long the probability of finding a book is greater than the cost of such a trace divided by the value of the book.

Using staff estimates as to the length of time it takes to search in the stacks, and in the files for a book, it was determined that at Tufts the probability of finding a book in the stacks and in the files should be approximately .02 and .005 respectively before any one area merits a trace.

Using these criterion one checks the data to see how close the staff came to these limits. At Tufts, tracing in the stacks on the third trace yielded only a one and two percent success for misshelved and correctly shelved books respectively. The total, three percent, puts the system rather close to the allowable limit of 2% probability for the stacks. For the files there is a four percent chance of finding a book, whereas the allowable limit is about half a percent. This means that there is a good leeway for expansion of the number of traces in the files.

If data is sufficiently large it is possible to use another computer program to pinpoint the optimal number of traces which should be made, ie. the amount by which one should expand the present number of traces. From the cost criterion it was established that one traces in an area as long as C/V p_n=the probability of success of the nth trace. Remembering that $F(t_n)$gives the number of books found on the nth trace, $p_n=\frac{F(t_n)-F(t_{n-1})}{\#\text{of books in study}}>C/V$.

Given optimal spacing for each sequence, one merely expands the number of traces until $\frac{F(t_n)-F(t_{n-1})}{\#\text{ of books in study}}<C/V$.

This process can be readily evaluated by using several programs available upon request from the author. These programs exhaust the different possible optimal spacing patterns and their attendant probability of the success on the last trace. Simple perusal estab-

lishes both the optimal number and optimal spacing of such traces for any given system.

One should then compare these optimal solutions with the previous method used. At Tufts University, criterion indicated that one should increase the number of traces by two, in the comparitively inexpensive to search files. This implies a twenty-five percent reduction in book-weeks lost over the old system consisting of tracing with an optimal trace spacing solution consisting of tracing on the 1st, 2.5th, 4th, 6th, and 9th weeks.

CONCLUSION

The S.P.S.S. program run for Tufts suggests education as a means to improve what seems to be slow response rates in the missing file, misshelved books and specially located books. Recognicance as to the high proportionality of the missing file's success, increased rigor in searching ten to fifteen books on either side of a book's correct location, and user education as to the importance of noticing whether or not a book is earmarked for a special location should save both staff and users from a lot of aggravation and time lost. In addition, statistics indicate that if students would check again after a day or two have gone by to see if the book they want traced has turned up on the shelf, they would avoid what seems to be the greatest proportional contributer to book-weeks lost; that is internal bookhandling. A hand-out to inform users of the aforementioned problems would perhaps be the most effective way to acheive such an education program.

Increasing the number of traces in the file areas and using the optimal spacing patterns suggested, a cut-back of over twenty-five percent book-weeks lost, can be realized in the Tufts University system. Similiarly, any library investing in a program of evaluation, such as the one outlined here, should find a satisfying increase in user benefits while keeping a check on staff costs.

ACKNOWLEDGEMENTS

The author is particularly indebted to Peter Berry, who is the staff member currently in charge of tracing at Tufts University, for his conscientious collection and collation of the traces used for this report. Mrs. Siegenthaler, Mr. Beale, and Mr. Homidar also merit a note of thanks for their cooperation and advice.

AUTOMATED LIBRARY SECURITY SYSTEMS: EXTRAVAGANT OR PRAGMATIC ?

a.b. karlin, l.d. solomont, n.a. tanana

ABSTRACT

The purpose of this study is to investigate whether or not Wessell Library has a problem of yearly book loss that is large enough to warrant the installation of a sensitized security device. Our investigation has shown clearly that a sizable problem exists. Our report is divided into three sections. The first analyzes the workings and effectiveness of the available systems. The second describes the problems and solutions that local-area libraries have found. (Most of this information was collected during interviews with the staff of the various libraries). The third section of the report evaluates the deterrent systems with respect to Wessell's individual economic and physical problems regarding book theft.

INTRODUCTION

The problem of theft in libraries has increased dramatically in recent years. Several companies have risen to the challenge of designing and building efficient electronic systems which are deterrents to book theft, and many U.S. libraries have chosen to take advantage of these automated devices despite the costs involved. Our investigation of the situation has led us to the belief that the library security problem is large and that the remedies are basically effective, though not foolproof. Should Tufts University make the investment? Will the returns reaped justify the money and effort spent?

ANALYSIS OF LIBRARY DETECTION SYSTEMS: COST AND EFFECTIVENESS

To cope with these problems of book losses, libraries have installed electronic equipment which can detect books being removed without being properly charge out. Several such systems which we have investigated and analyzed include the 3M Tattle-Tape Book Detection System, the Remington Rand Book-Mark System, and the Checkpoint Mark I and Mark II Library Security Systems.

The theories of operation of these models differ with regard to the method of sensing the book passing through the system; but all have the same essential objective: to detect a book which has not been properly charged out.

These systems fall into two categories: "bypass" and "full-circulation" systems. To initiate either of these, first a portion of the library collection must be sensitized. In most cases, this is done by placing a thin strip or book plate made with a sensitive material in each book.

The library staff then reshelves the books; and from this point on, all operations proceed as usual. When someone wishes

to borrow a book, it is taken to the circulation desk where the librarian processes the book as usual. In the case of a bypass system, if the circulation desk is set up at the exit, the librarian simply hands the book to the borrower around the sensing screen. The person is then past the device and will not trigger the alarm. Had the borrower neglected to give the librarian all the materials that s/he wished to charge out, the alarm would have been triggered, and the turnstyle locked. This system is called a bypass system because the librarian must pass the book around the security device.

A full-circulation system differs from the bypass method in that the books can be desensitized at the circulation desk and carried through the sensing devices without triggering the alarm.

There are several problems inherent in both these systems. A bypass system requires that someone be at the sensing units, which are typically located at the exit. If the circulation desk is immediately at the exit, this presents no problem. If the circulation desk is not at the door, each time a patron returns to the library with a charged-out book, the guard must recheck the book when the patron leaves so that the book cannot trigger the alarm. The full-circulation system alleviates these problems. It provides the facility for books to be desensitized. During the charge-out process, the librarian desensitizes the book so the borrower is free to re-enter the library at will. It also eliminates the necessity of a circulation desk at the exit; a guard would not be essential to recheck the books.

The 3M Tattle-Tape Book Detection System is a bypass system. The cost for all of the hardware is $17,500 which includes the sensor, turnstyles, and controls for the system. A book is protected by a $.16 metal target. There are several deficiencies in the 3M system. Holding the book at the proper level or angle will allow a borrower to take a book without completing the proper charge-out procedure. The sensing device is essentially a magnetic detector, which creates the problem of an unwarranted number of false alarms.

The Checkpoint Mark I Library Security System is also a bypass system. The cost for the hardware is $4,600 which includes the sensor, turnstyles, and controls. A book is protected with a $.165 metal target. This system is also a sophisticated metal detector which accounts for the occurrence of a large number of false alarms. The range of sensitivity is limited to a smaller area than other devices, allowing library users to easily avoid the system. Because of the deficiencies in the Mark I system, Checkpoint has recently introduced the Mark II Library Security System. This can be set up as either a bypass or a full-circulation system. The cost of the hardware is $5000, and this includes the sensing devices and turnstyles. Each book target costs $.10. [1]

If this system were to be implemented as a full-circulation system, there would be an additional cost. In order to desensitize the book, the librarian would place an additional tag in the book. This desensitizing tag would be put in the book during the charge-out procedure and removed when the book is returned. The cost

for these additional tags would be $.005 a piece. This system as a bypass sytem requires that the circulation desk be adjacent to the door. Problems exist when the Mark II is used as a full-circulation system; for the desensitizing tags are easily removed, allowing a would-be "long-term" borrower to remove a tag and place it in another book in order to desensitize it.

As a bypass system, the Mark II is nearly foolproof. This is primarily because the method of sensing is completely different than the magnetic field detection or metal detection systems. It seems, in addition, to be the simplest system to operate, though it does requires that the circulation desk be near the exit.

The final system we considered was the Remington Rand Book-Mark System. This is a full-circulation system. The cost of the hardware is $20,000; and this includes the sensing units, controls, traffic counter, alarm, automatic turnstyles, and three sensitizing and desensitizing units. The cost of the targets depends on the type desired. The targets are priced as follows: plate-type—$.08, spine-type—$.10, and double-adhesive periodical-type—$.15. This system provides all the advantages of a full-protection system while being very reliable. As books are charged out, they are passed over a desensitizer which will permit the book to be removed and brought in without setting off the alarm. As the books are returned, they are passed over a sensitizer. The system is essentially a magnetic field detector. To eliminate unnecessary false alarms, magnetized items are to be desensitized on the book desensitizer. This prevents an item that is not a book from triggering the alarm. The system also has provisions for multiple-exit control from a central location. [2] See fig. 1.1

No system will be foolproof because there will always be people who will try to bypass it. An important factor, though, is that an automated detection system will save the library a considerable amount of money in the long run. More important is that a library's collection will contain that many more books for the use of its patrons.

USE OF DETECTION SYSTEMS IN VARIOUS LIBRARIES

In addition to the workings of each security system, we investigated various Boston-area libraries and their security systems. We also corresponded with other U.S. libraries across the country. At each of these libraries, our intention was to assess the varying security problems and to subsequently relate these difficulties to those of Tufts' Wessell Library. Hopefully, the experiences of these libraries can help Tufts' staff to attack their security problems more objectively and wisely.

Our first stop was library A. The building was rather old with many separate rooms and an abundance of windows with no screens which could be easily opened by patrons. Presently, Library A has the 3M Tattle-Tape system and has met with great success relative to their previous situation.

Library A has approximately 280,000 volumes. Prior to the installation of the 3M system, the library was enduring a yearly

BEST COPY AVAILABLE

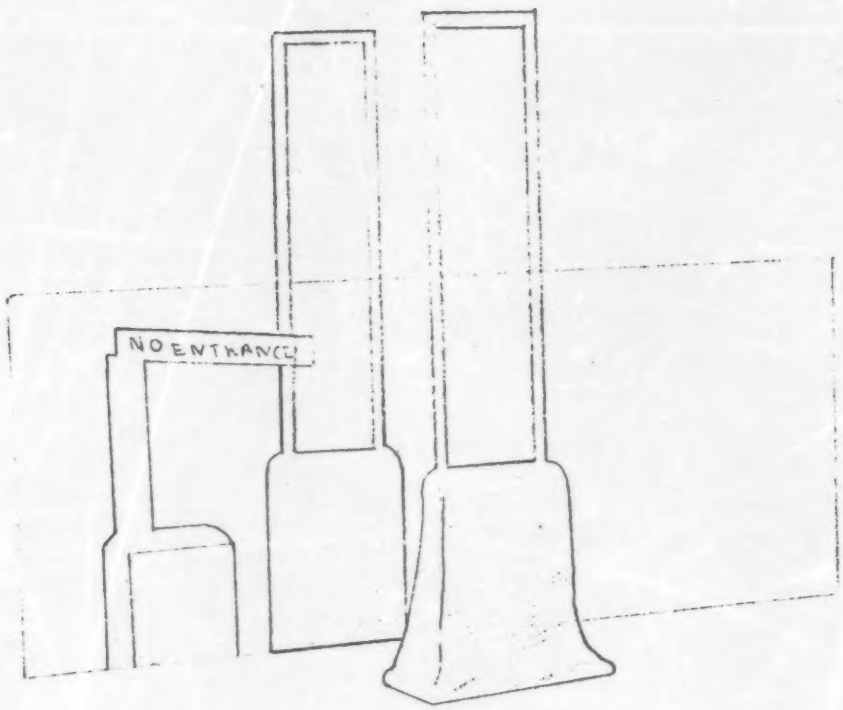


Figure 1.1

Screen Senser with Locking Gate

book loss of about 8%, some stolen, some misplaced. [3] Monetarily, this meant a $358,400 annual loss (calculated at $16/book= cost+ processing--the cost we will assume for all undergraduate libraries). Certainly, their former security system--six security guards--was proving rather ineffective. As one of the library personnel explained, there were several reasons for the large amount of loss via theft. Library A had two main exits and several "sub" exits. The abundance of exits definitely increased their vulnerability to theft. In addition, students had been often known to remove books through open windows (one reason newer libraries, including Tufts, have air-conditioning and sealed picture windows). Library A's guards were sufficiently negligent to be considered ineffective to combat book theft. In fact, one had been known to doze off sporadically.

In general, then, the operation of Library A was in jeopardy. Its important service to the community was threatened by the very population it was attempting to serve. Too many people could not find the volumes they needed.

And, so, after consideration of several automatic security systems, the 3M Tattle-Tape device was chosen and installed. At present, only about 16% of the entire collection (around 45,000 volumes) are protected (at $.16/book=$7200); and this small amount of protection has resulted in an approximate 50% reduction in loss (determined by a sampling of high circulation books--about 2% of the collection). [3]

In any case, the estimated drop from 8% to 4% is sufficient to justify the 3M cost, even though the guards have been retained. Costs look something like this:

Rental/yr. till purchase	$6600
Protection all new items	6500
Guards salaries	21,626
	$ 34,726/yr. [3]

Of course, this does not include the initial $7200 tagging fee; yet either way, these costs surely are justifiable in the light of a $179,200 savings in books and more volumes on the shelves. Once purchase is complete, the yearly cost will also be further reduced.

The people at Library A have been pleased with the results of Tattle-Tape. There have been no public relations difficulties; in fact, the stricter attitude has motivated an increased respect for the services the library offers. False alarms have been a problem (the nearby subway system has caused some interference). Although the system is not foolproof, for the run-of-the-mill student crook, it is an effective theft-prevention device.

Library B is a medical,dental library and has had the 3M system for two and a half years. Their problem was mammoth nearly beyond comprehension. They had a 23% yearly loss of their 60,000 volumes at an estimated $525,00 per year (approximately $30/book since almost all are scientific texts). Most of the stolen books included new texts and bound journals. Bound journals are difficult to replace, thus incurring an other-than-monetary expense to Library B. Apparently, most theft was caused by students, though the very urban setting of this library could indicate outside theft.

In any case, the justification for installation of a 3M system seems clear. Library B bought the system. They randomly protected about 50% of their collection (30,000 books at $.16/strip=$4800), and personnel at the circulation desk monitor the system at the one exit. Thus, the initial cost was approximately $25,000, and their yearly additional cost for protection of 4500 new yearly acquisitions is $720.

After two and one half years, Library B has cut its loss of new books from 23% to 5%. [3] Extending this statistic to the general collection, we can expect that loss has been cut to less than 5% since new volumes (along with bound journals) are perhaps the "hottest" items of the collection. This decreased the lost book fee from $525,000/year to around $90,000/year--certainly much better, but by no means a trivial expense.

Our next visit was to a small college in a rather quiet, rural area. The statistics we collected from the head librarian were somewhat sketchy since the staff had not yet completed an up-to-date inventory. However, since the general feeling had been that a large percentage of their 60,000 volumes were missing, Library C's administration decided to purchase an automated device for their one exit (which had always been unguarded). After lengthy investigation, they decided to purchase the early model Checkpoint system at a $4600 cost. Due to the business and management emphasis of their curriculum, Library C's staff tagged all social science volumes and approximately 45% of the remainder of the collection. They tag all new acquisitions (4500 books/year at $.165 per tag=$745/year). In addition, many books have dummy tags in them.

Library C has had their Checkpoint system for one and one half years. They have not, as yet, completed statistics showing changes in loss, but they feel confident that the loss has been reduced and that the initial and yearly costs have been worth monetary and service savings. Many fewer people are complaining about missing books. Although the system is not foolproof, as has been pointed out, it is an effective deterrent to theft. The majority of users will not go to the bother of attempting to outwit the system.

Library D, situated in an urban setting, also recently installed a Checkpoint system to protect their 150,000 volumes. Their yearly book loss had been estimated at .6%--or a yearly loss of $14,400. The claim is that theft has been cut to virtually 0%. This claim is questionable, since though all new acquisitons are tagged, only a small percentage of older books have yet been protected. The librarian we interviewed expressed his belief that most students do not know which books are tagged. This ignorance, he felt, has helped the system to be effective until now.

Library E is in the process of installing the Remington Rand Book-Mark System. A staff member informed us that though it is difficult to assess the percentage of the 70,000 volumes which are lost or missing, the noticeable increase in complaints concerning missing books warrants the installation of the device.

This brings us to a question of philosophy. At Library E the monetary loss was not determined exactly. The staff feels that each volume has more than monetary value attched to it. If an important, quickly-circulating book is missing, the services the library offers become limited. To many a librarian, then,

their best service to the public is worth the highest costs of machinery and manpower.

At Library E, 30,000 of the volumes will be sensitized. Library E is the only New England library that has purchased such a system. We did contact non-local libraries and received some information from a small California college which recently installed a Book-Mark system. They claim that after installation of the system, book loss was reduced 75.2%. Their first year savings approached $14,500.[7]

Besides investigating automatic systems, we felt it would be beneficial to look into various "manual" security systems. Library F came to mind immediately. Library F's security has an eventful history attached to it which we were able to learn about. In the early 1900's, Library F had stacks closed to all; students and public alike. If a registered student wanted a book, he had to request a stack employee to locate it and hand it over. There were no exit guards and no one but students registered in the University could check out books. Apparently, one gentleman developed an elaborate means by which he was able to steal over 1500 books. He was discovered when a prospective buyer of a used book, noticed the Library F stamp on the volume. The "rogue" was apprehended, and Library F began their very strict guard system which remains to this day. The stacks are now open to enrolled students only. Library F, then, is theoretically an open stack (not to the public) library with a rather effective guard system which "syphons" people out of the one exit. Traffic patterns and the layout of the building allow this system to work well. Library F has 3,000,000 volumes and adds approximately 60,000 acquisitions yearly. One librarian indicated to us that an inventory is considered next to impossible. Thus, there are no available book-loss statistics; yet the librarian was confident that the loss factor is minimal and that present security measures are effective. Under consideration, presently, is the proposal to halt all circulation outside of the library so that all books will be available nearly full time.

In correspondence with the business manager of Library G, one of the pioneer users of the 3M system, we have learned that their security problems (loss of $30,000-$50,000 per year) led them to install their system. Though there are false alarms, Library G has found the system to be a beneficial aid to serving their students and have saved on manpower. (See Figure 2.1)

The Levittown Public Library has issued an extensive report on library security. Their samplings indicated that with 100% protection, the 3M system can eliminate up to 81% of the book loss; 50% coverage showed a 78% loss reduction; 25% coverage indicated between 50-75% reduction; 10% coverage resulted in a 60% reduction. This last statistic is one which samples books which were randomly tagged. When there was 10% coverage of books selected by the staff, the loss reduction reached 69%. The Levittown report also indicated that loss of unsensitized books within the 3M system was also down approximately 50%.[4]

Random or staff-selected tagging can be controversial. Levittown Library conducted time studies which indicated that with Tattle-Tape the former method cost $.032 per item in manpower;

Library	System	Yearly Book Loss		#Volumes	Monetary Loss		Cost Extra Sec. Employees		Exits
		Before	After		Before	After	Before	After	
A	3M	8%	4%	280,000	$358,000	$179,000	$21,626	$21,626	2
B	3M	23%	5%	60,000	$525,000	$ 90,000		0	1
C	Checkpoint Mark I		Cut	60,000			0	0	1
D	Checkpoint Mark I	.6%	0%	150,000	$ 14,400	$ 0	0	0	1
E	Remington Rand Book-Mark			70,000			0	0	1
F	Manual Guards	low	low	3,000,000	Negligible		$30,000	$30,000	1
G	3M	2500 books			$ 40,000	Cut			

Fig. 2.1

the selected tagging cost $.092 per item. [47] These charges will be in addition to the $.16 cost for each strip.

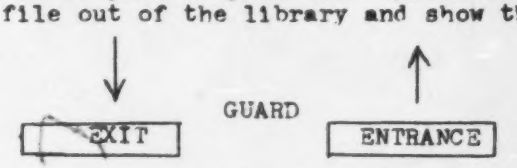
Unfortunately, the Levittown report focused on the 3M system. However, the findings are likely to follow in other situations. In general, then the report supported the widely-held notion that theft deterrent systems in libraries are cost-effective and beneficial. This is the general feeling we also had after visiting the various libraries. In each case, book loss has been reduced enough to credit the systems as powerful adn effective. In addition, the devices are becoming more and more popular. Before 1970, perhaps only one half dozen U.S. libraries had automated devices. Since then the need has grown and so has marketing and purchasing of the systems.

WITHER WESSELL?

Other college libraries have realized their security problems and found solutions to them. We have investigated the Nils Yngve Wessell Library at Tufts University.

Periodically, members of the Wessell staff sample books to determine what is in the library and what is missing. For the past few years the figure of 1.1% missing books has been recorded annually. In the last count this figure had increased to 1.8% This "missing" figure includes books mis-shelved as well as those stolen from the library. This 1.8% of 250,00 volumes gone from the library collection means a $72,000 annual loss. Many of the books will not be returned to the collection; either the "thief" will never return the book, has himself lost or damaged it, or questionnaires sent to related academic departments will go unanswered meaning faculty does not think the book important enough to be reordered. Wessell is losing books, time, and money. A security problem exists.

There is presently a guard system at Wessell whereby people file out of the library and show the guard their material.



The guard makes sure books marked with the "Tufts University" stamp have been correctly checked out. Why should Wessell have a security problem, then? One reason is that the guards are ineffective in stopping theft. In a small sample survey of Tufts students, it was found that some admitted having taken books from the library without using proper checkout procedures. Many students said the guards do not check them and sometimes were asleep. Students often exit through the wrong door; and when more than one person exits, the guard often checks the person closest to him while the other(s) pass by. Women's purses are seldom, if ever, searched. How many chances there are for someone to "steal" a book!!

Small survey of students at Wessell Library

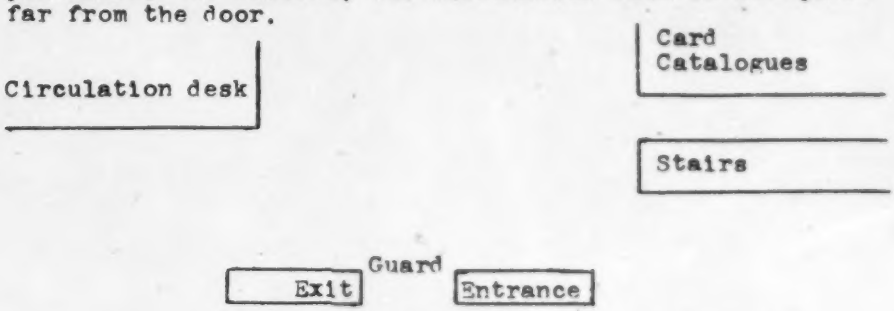
Question 1: Do you think a security problem exists in Wessell Library?
No:16 Yes:8 No Answer:4

Question 2: Have you ever taken a book from the library without properly checking it out?
No:24 Yes:4

Question 3: Would you be opposed to the installation of an automated security system?
No:23 Yes:5

How might Wessell cut their book theft? One solution could be to strenghten the guard system. The problem is How to strengthen it. Library doors cannot be made to be one way due to Fire Regulations. A turnstyle could be set up at the exit to permit a check of singly-filed persons. But if the guard still does not search completely, the turnstyle will be worthless. Wessell hires retired men for guards at $2.35/hr, 120hrs/wk = $12,000/yr for ineffective guards and a $72000/yr. book loss. Ther are no statistics to see if women checkers might be more effective. No one can just tell these guards to be more conscious about book theft and expect a drop in book theft. Something more has to be done , especially if theft continues to rise.

Humans cannot thoroughly do the job. Therefore, we looked into the aforementioned library security systems. At several libraries we visited the security systems are set up at the circulation desk so that books are by-passed by the library staff as one easy step of the check out procedure. At Wessell, the circulation desk is set quite far from the door.



There is almost no possibility of moving the circulation desk because of limited space. If a by-pass system were set up by the door, users would have to check out books at the circulation desk and have them rehandled and checked by those guards.

What Wessell needs is a full-circulation system such as the Sperry Rand Book-Mark system. By tagging about 25% of all books, book theft will be cut by 50%, no worry about moving the circulation desk as the books will not have to be by-passed at the main exit. The guards, although not necessary for operation, can remain if only to be awakened by the system alarm.

CONCLUSION

Who wants yesterday's papers? Who wants to lose money if they don't have to? Why should many suffer the evils of a few?

One would think a $72,000/yr rising loss to be significant. This is more evident when one realizes this means a 4,500 books gone/year, and closer to home, over 12 books/day missing. Doesn't this mean something to someone? Doesn't this inconvenience more than one user? And there is no end in sight to the rising book loss. College is becoming more competitive. It is getting more important to have "that book."

The Sperry Rand Book-Mark system will hopefully stop "that book" from leaving the library by illegal means. The "book" will remain as part of the collection.

For a $20,000 initial set cost for the Sperry Rand system, plus $6,250(not including labor) to install targets in 62,500 volumes(25% of the 250,000 volume collection), letting the guards retire gracefully(saving $12,000), Wessell will save in the first year: $72,000/2(minimum loss-cut) plus $12,000(guard savings), minus the costs of the system, $20,000 plus $6,250. This is a $21,750 savings to Wessell in the first year alone. Money talks.

It seems pretty obvious to us that the Wessell library should seriously consider the Sperry Rand system as an alternative to the guard-and-book-loss system presently in use.

ACKNOWLEDGEMENTS

These people all helped us in their own way:

E. Willer
J. Komidar
G. Beal
W. Rouse
W. Hicks
K. Tye
M. McCloud
D. Harkavy
F. Cannon
C. Rosen
E. Levitt
F. Jones
M. Boudreau
and Dave Dobson

Proposed Automated Systems for Wessell Library

	INITIAL COST[1]	COST/ TARGET	TARGET INPUT[4]	RESULTS
Checkpoint Mark I	$4,600	.165	$10,312.50	cannot be easily implemented due to the location of circulation desk
Checkpoint Mark II (full-circ)	$4,800	.11 .005[2]	$7,187.50	very clumsy as full-circ model, removable tabs
3-m Tattle-tape	$17,500	.16	$10,000	cannot be easily implemented due to the location of circ desk
Sperry Rand Book-mark	$20,000	.10[3]	$6,250	best all-around system for Wessell w/$21,750 first-year savings

1) Sensing hardware
2) Additional cost for desensitizing labels
3) Spine-type targets most efficient
4) Costs based on tagging all reserves, highest circulated books, and all new acquisitions(25% of all volumes)

REFERENCES

[1] Checkpoint Mark II "No Headache" Library Security System. Checkpoint Systems, New Jersey.

[2] Problem: Book Theft, Solution: Book-Mark, Library Bureau Division of Sperry Rand, New York.

[3] Willer. "Library Security Report". 1973.

[4] Sheridan, Robert and Martin, P.W. Results of Tests Conducted to Determine the Need for a Book Theft Deterrent Device and the Ability of the Tattle-Tape Electronic Book Detection System to Reduce Theft. Levittown, New York, November, 1972.

[5] "Book Bugging: Possible Answers to Library Theft." Science. January 23, 1970..

[6] Schefrin, Rita. "The Barriers to and Barriers of Library Security." Wilson Library Bulletin. H.W. Wilson Co., New York, May, 1971, pp.870-877.

[7] Library Annual Report, California, 1972.